



GENERAL SCIENCE

INTERMEDIATE: BOOK 2

J. A. PARTRIDGE

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GENERAL SCIENCE

Intermediate: BOOK 2

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GENERAL SCIENCE

For Intermediate Grades

Intermediate: BOOK 1 } by
Intermediate: BOOK 2 } J. A. PARTRIDGE

Intermediate: BOOK 3 } by H. BOWERS and
Intermediate: BOOK 4 } R. N. BISSONNETTE



GENERAL SCIENCE

INTERMEDIATE: BOOK 2

J. A. PARTRIDGE

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J. A. P.

TO THE TEACHER

The content of this book is based upon the Outlines of Courses for Grade VIII of the Intermediate Division of Ontario Schools, the programmes of study of other provinces of Canada, and curricula drawn up by various local curriculum committees.

The book presents a more comprehensive programme of study than can be covered in one year. No attempt has been made to classify the subject matter into topics of general interest to all pupils, and optional topics in which the degree of interest may vary in different localities. To the teacher has been left the responsibility of selecting for careful study those topics and subtopics that are most closely related to the past experiences of the pupils, and that are likely to serve their future interests best. Other parts of the text may well be treated as supplementary reading.

The ever-increasing complexities of our times make it imperative that every girl and boy should have some understanding of the basic principles of science and an appreciation of the contributions of science to man's welfare. A pupil's understanding of scientific principles and of the values of science in everyday living will be superficial indeed unless it is acquired through personal experiences and applied to phenomena in the immediate environment. To this end, the "scientific method" has been kept to the fore throughout the book by means of a wealth of experiments, investigations, and research activities for pupils to perform at school or at home. All have been planned for average classrooms and homes where little special equipment is available. A serious attempt has been made to integrate the activities closely with the basic principles of science and with information useful in daily living.

The content of the text is organized in ten units, each related to an important area of scientific learning. A full-page illustration and a brief preview of the subject matter of the chapters included introduce each unit. These may well be discussed before proceeding to study the chapters in the unit.

The principles and methods of conservation of our natural resources are stressed wherever an opportunity presents itself. The conservation of soil, water, and forests, studied in an organized manner in *General Science*, Book 1, is reviewed and applied to the ever-present problem of conserving our diminishing wildlife resources through wise use and timely protection.

Sound films and film strips are listed at the end of most chapters. Many of the sound films may be borrowed by schools in Ontario, without charge, upon application to *The Visual Education Branch, Ontario Department of Education, 244 College St., Toronto*. The film strips listed are available only by purchase from the sources indicated. In provinces other than Ontario application for a list of films and film strips should be made to the Film Library of the Department of Education.

A number of significant words, related to its content, are listed at the end of each chapter. It is essential that pupils master both the spelling and the meaning of these words or groups of words before proceeding to the next chapter.

The true scientist is a questioner, an investigator, an experimenter, and a thinker who accepts statements only when their accuracy has been tested and proven, and who draws only such conclusions as may be established upon the evidence assembled. As pupils study science, they are, in this sense, training to be scientists. Their methods of study must, therefore, follow the methods used by scientists. The author will consider his efforts well repaid if this book helps pupils, in some small degree, to develop such a scientific attitude of mind.

J. A. P.

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MESSAGE TO GIRLS AND BOYS

*Step by step, since time began,
I see the steady gain of man.*

WHITTIER

Did you ever stop to think how important a part you can play in bringing about this "steady gain of man"?

Through the ages man has steadily learned more and more about nature—about the earth and its waters; about the earth's blanket of air; and about the multitude of living things that inhabit the earth. Gradually, man has discovered the nature of air and fire and ways in which they may serve him. He has learned much about the living things of the earth—how they live; how they depend upon each other; and how they can be made useful to him. Man's search for such knowledge is called science, and science has brought about much of his progress.

Soon the challenge to carry forward the "steady gain of man" will be yours. It will be your privilege to discover new truths about the earth and all things thereon, whether they be living or non-living, and to make your contribution to man's knowledge, understanding, and control of his environment.

This book has been written to help you prepare for your task. While you read the book and follow some of the suggestions given in it, you will learn in the short space of one year much that those who preceded you discovered through centuries of investigating and experimenting. As you make investigations and perform experiments suggested in the book, some by yourself and some in groups, you will learn how the scientists before you made their discoveries. At the same time, your experiences will teach you how to make new discoveries by yourself, both now and in later years.

Think of your teacher and yourself as partners as you use this book. Your teacher will serve as a guide. Together, you will read, think, investigate, perform experiments, talk over your discoveries, and answer the questions placed before you—then, perhaps, other investigations that you can make by yourself will occur to you. May I, too, through this book, be a partner in your explorations and discoveries, and may I wish both you and your teacher a full measure of success and satisfaction in your investigations!

J. A. PARTRIDGE

UNIT ONE

Animals Are Adapted To Live in Many Kinds of Environments

1. *HOW INSECTS ARE ADAPTED TO THEIR SURROUNDINGS*

Insects inhabit every part of the earth. They have accommodated themselves to all kinds of conditions. Some live on vegetation, some in soil, and others in water. The habits and structures of all adapt them well to feed, breathe, travel, and reproduce.

2. *MAMMALS AND BIRDS HAVE THEIR SPECIAL ADAPTATIONS*

Mammals and birds are the only warm-blooded animals. The former are covered with hair; the latter, with feathers. Some mammals are adapted to live on land; others, in water. The structure of birds fits them well to fly. Special habits and structures adapt each kind of mammal and bird to live successfully in the environment in which nature has placed it.

3. *HOW SOME OTHER ANIMALS ARE ADAPTED TO THEIR ENVIRONMENTS*

Each type of animal has survived only because Nature endowed it with those habits and structures that enable it to feed, breathe, and travel in its particular surroundings. Earthworms thrive in moist, rich soil; snakes and other reptiles live chiefly on land; fish can live only in water; and frogs and toads must have both land and water.

The photographs on the following page show a walking-stick insect resembling twigs, a great blue heron nearly hidden by rushes as it watches for fish, and a spotted young elk, difficult to see in shrubbery.



1

HOW INSECTS ARE ADAPTED TO THEIR SURROUNDINGS

“And there’s never a leaf nor a blade too mean
To be some happy creature’s palace.”

James Russell Lowell

THE LEAVES OF A TREE OR SHRUB, the centre of a flower, blades of grass in meadow and lawn, the space under a log or a stone, the ground itself, the water of a pond, even the fur of a cat and the hair of a dog—all these may be the homes of insects. We can find insects almost everywhere we look. They outnumber all other animals taken together. Surely their ways of living must fit them well to thrive in their chosen surroundings! In this chapter, we shall try to find out how a few insects are adapted to their environments.

The Grasshopper

Grasshoppers are found commonly in meadows, pastures, and waste places. To learn about their habits and their adaptations, we should study them where they live, then get a closer view of them in the classroom.

PUPIL INVESTIGATIONS. 1. *Observe grasshoppers in their natural environments.*

Go where grasshoppers are quite plentiful. Which sees the other first, you or they? Try to find out how they learn of your approach. Estimate the average distance that a grasshopper jumps when it is disturbed. With what legs does it take off? Find the little claws that keep the grasshopper from slipping back. Notice the large, muscular nature of the upper part of the hind legs.

How does a grasshopper know where to alight? Find the two large eyes on the sides of the head. Notice the tiny parts that make up each eye. Because of these many parts, the eye is called a compound eye. Each little part can see straight ahead of it. How do the position, size, and shape of the compound eyes make it possible for the grasshopper to see in all directions?

Notice how the wings are spread when the grasshopper is flying.

Why is it difficult for you to see grasshoppers before they jump or fly? Look for small grasshoppers without wings. Try to find grasshoppers that are chiefly brown and others that are chiefly green. How do their colours compare with their surroundings? How does this similarity in colour protect grasshoppers from their enemies? How does the position of a grasshopper on a plant stem keep the insect from being noticed?

Do grasshoppers bite out pieces of a plant or merely suck its juice?

2. *Prepare a grasshopper home in the classroom to enable you to make closer observations as you read further.*

Lay some sod in a glass container, or in a box in which you have fitted one or more glass sides. Place several grasshoppers within. Keep the soil merely moist so that the grass will continue to grow.

A Grasshopper Is Well Adapted for Protection and Travel. To live, the grasshopper must eat; to eat, it must travel about. Throughout its life, as the grasshopper travels in search of food, it is exposed to the attacks of its enemies. However, the insect has certain characteristics that protect it. Because its colour resembles its surroundings, it is less likely to be seen; when necessary, it can fly or jump to safety; even after being caught, it can discourage its attacker by spitting on it a disagreeable brownish liquid.

PUPIL INVESTIGATIONS. *Catch a grasshopper and examine its wings without injuring it.*

How are the outer wings fitted to protect the under ones? How do the under wings open for flying? What characteristics make the under wings both strong and light? How does the place of attachment of the wings to the body enable them to lift it with perfect balance?

The grasshopper is well adapted for flying. The wings used for flight, when unfolded, are large enough to press against a large area of air at each stroke; the thin membrane makes them light; the supporting veins give them strength. When not in use, these wings are protected from injury among plants by being folded beneath the tough front wings.

PUPIL INVESTIGATIONS.

Feel the covering of the grasshopper's body to discover why it is not injured when it alights among sharp-edged grass blades.

The outer covering of a grasshopper is hard enough and tough enough to protect it from cuts and bruises. Because this tough skin gives the insect its characteristic shape, it is called an outer skeleton or an *exo-skeleton*. It is so divided that it gives the insect's body three main parts, namely: the *head*, bearing the mouth, eyes, and feelers; a central part, the *thorax*, to which the wings and legs are attached; and the *abdomen*, the tapering part behind the legs. Joints in the *exo-skeleton* divide the abdomen into *segments* and make it flexible.

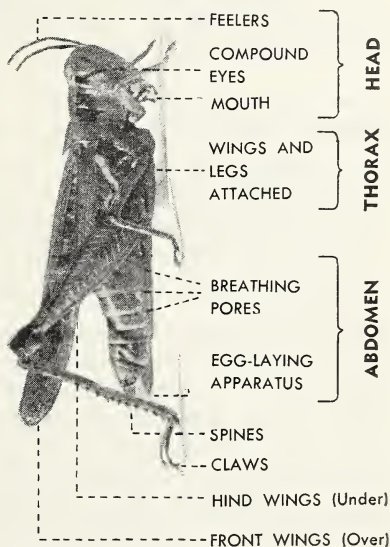


FIG. 1-1. ADAPTIVE STRUCTURES OF A GRASSHOPPER.

A Grasshopper Is Well Adapted To Climb and Cling to Stems and Leaves To Feed.

PUPIL INVESTIGATIONS. *Find out how grasshoppers climb stems and leaves.*

Which legs do they use most? Examine a grasshopper's legs and feet to find what keeps it from slipping down stems. To understand how grasshoppers climb on smooth rocks, notice how they cling to the glass of the grasshopper home you made.

Watch a grasshopper feeding. What is the advantage of its jaws moving sideways instead of up and down as ours do?

While feeding, the grasshopper clings to the stems or leaves of plants by using its two front pairs of legs. The claws on the feet help the insect to climb and keep it from slipping. Since grass blades are usually vertical, it is well that a grasshopper moves its jaws sideways as it uses their hard, rough edges to bite pieces from the plants. In addition to its two large compound eyes, a grasshopper has three small eyes which enable it to see what it is biting.

How a Grasshopper Breathes. To live, a grasshopper must breathe. It takes in and gives out air somewhat as we do.

PUPIL INVESTIGATIONS.

Look for small breathing pores along the sides of the grasshopper's body. Do they open and close? Air enters these pores and circulates through little tubes to most parts of the body.

Study fig. 1-1 as a review of the adaptations of a grasshopper.

The Life History of a Grasshopper. Grasshoppers lay eggs in the late summer and fall. The female works the end of her body an inch or two into the soil as shown in fig. 1-2 and lays the eggs under the surface of the soil. With the eggs, she deposits a liquid which hardens into a protecting case or pod. One female deposits several pods of fifteen to one hundred eggs each. With the return of warm weather, in April or May, the little grasshoppers hatch and work their way out of the eggs, then out of the ground.

The young grasshoppers, much like grown-up grasshoppers except that they lack wings, are called *nymphs*.

The growth of grasshoppers takes place in the nymph stage. As a nymph feeds and grows, it becomes too big for its skin. The old skin splits and is shed, and the new skin, already formed beneath it, stretches for a while and then becomes tough like the old one. Before the grasshopper becomes a full grown *adult*, it changes its skin (*moults*) five times. During this period of time, the nymph develops wings like its parents.

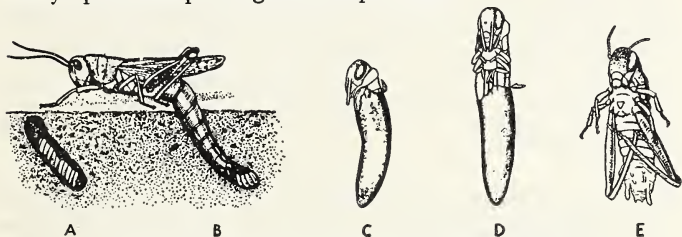


FIG. 1-2. THE LIFE STORY OF A GRASSHOPPER.

A, a buried cluster of eggs; B, a grasshopper laying eggs; C and D, a young grasshopper (nymph) working its way out of an egg; E, the wingless nymph, ready to hop away and eat.

Grasshoppers Are Harmful. Reports of damage to man's crops by grasshoppers date back to Bible times. They are described as having darkened the sky and, with a deafening roar of wings, settled down to feast. As they moved forward like an army, they devoured every green leaf, becoming one of the "seven plagues" of Egypt, which brought famine to that country. Grasshoppers are especially harmful in warm, dry seasons, and near grasslands in which they lay their eggs. They will feed upon almost any kind of vegetation when they have destroyed the more tender leaves of grain plants. Among crops attacked most commonly are pastures, oats, corn, clover, and garden vegetables.

When man cultivated the western plains of Canada and the United States, he created more favourable conditions for grasshoppers and, at the same time, destroyed the homes and nesting sites of the prairie foxes and birds that ate them. Since then, governments have spent millions of dollars to carry on the fight against the grasshoppers.

Grasshoppers Are Controlled by Nature and by Man. Grasshoppers have many natural enemies. The eggs may be eaten by ground beetles or mice, or prevented from hatching by unfavourable spring weather. Frequently the nymphs and adult grasshoppers are eaten by skunks, toads, and birds. Disease also comes to the aid of man in controlling these pests.

The farmer may destroy the eggs by late fall ploughing and disking. While the young grasshoppers are still near their hatching grounds, they may be killed by a poisoned bait consisting of a mixture of bran, sawdust, and white arsenic. This bait is scattered so thinly on the fields that grazing animals and birds cannot be poisoned by it.

Test Yourself

1. How do the habits and body parts of a grasshopper adapt it to:
(a) avoid detection by its enemies, (b) travel long distances, (c) avoid being cut and bruised when it alights, (d) climb and cling to grass stems and leaves, (e) eat grass blades?
2. Name the three stages of the life history of the grasshopper, and tell how a young grasshopper differs from his parents.
3. How does a grasshopper breathe?

The Honeybee

The life of a honeybee is quite different from that of a grasshopper. Instead of biting and chewing leaves for food, the honeybee eats nectar or honey, usually in liquid form. In its search for nectar from which to make honey, the bee flies long distances and much of the time. It gathers food, not only for its own use, but to be stored in its home or fed to young bees and, therefore, has to carry nectar and other foods home with it. It makes wax and uses it to build the comb in which the honey is stored. For these reasons, we would expect the structure of a honeybee to be quite different from that of a grasshopper if it is to be well adapted to carry out these special activities.

PUPIL INVESTIGATIONS. 1. *Study the habits of living bees.*

If possible, visit a beehive during the sunny part of a day. Otherwise, try to obtain a few living bees from a beekeeper and keep them in school for a while in a glass container. Feed them honey.

Observe bees flying to and from the hive. How does the flight of home-coming bees differ from that of outgoing bees? How many wings do bees use in flight? Look closely for evidence that the returning bees are bringing something with them. Try to find bees at the entrance to the hive moving their wings rapidly back and forth as if they were fanning the air.

Ask the beekeeper to let you see inside the hive. Examine the frames and the honey combs they support. Try to find cells of different sizes, perhaps a queen's cell. You may see the queen with the bees working on the comb. Look inside and outside the hive for bees that are larger and stouter than most of the others.

2. Examine a dead bee and compare its structure with that of a grasshopper.

What different divisions of the body can you see? Look on the head for feelers, eyes, and mouth. How many legs and wings are attached to the thorax? Compare the front and back wings. Look for yellow pollen on the hind legs. Try to find breathing pores along the sides of the abdomen. Is the abdomen made up of segments?

Members of the Honeybee Family. The beehive that you observed is the home of a very large number of bees living together as a family or colony. Nature has so planned bee life that each member of this colony contributes to the general welfare. Three kinds of bees make up the colony—the queen, the drones, and the workers.



FIG. 1-3. MEMBERS OF THE HONEYBEE FAMILY.

Left, a worker, the smallest; centre, a queen, the longest; right, a drone, stouter and larger than a worker.

The queen is the mother of the colony. Her life's work is to lay eggs. From spring until late autumn, sometimes at the rate of three thousand a day, she does so, but gives no care to the young bees. Her usual length of life is two to three years.

The drones, the gentlemen of leisure, do none of the work of the hive. Their one use to the colony is to fly out with the young queen on her wedding flight. The weak ones fall by the wayside, while the strongest one flies farthest and mates with the queen. This makes it possible for the eggs laid by the queen to hatch into new workers or queen bees. Without the drones, the colony could continue only for the life of this reigning queen. The drones themselves develop from unfertilized eggs laid by the queen.

The population of the colony consists largely of worker bees, numbering from ten to seventy-five thousand. During their short life of about six weeks, the workers serve as housemaids, nurses, porters, wax-makers, comb-builders, guards, food-gatherers, ventilators, executioners, even undertakers.

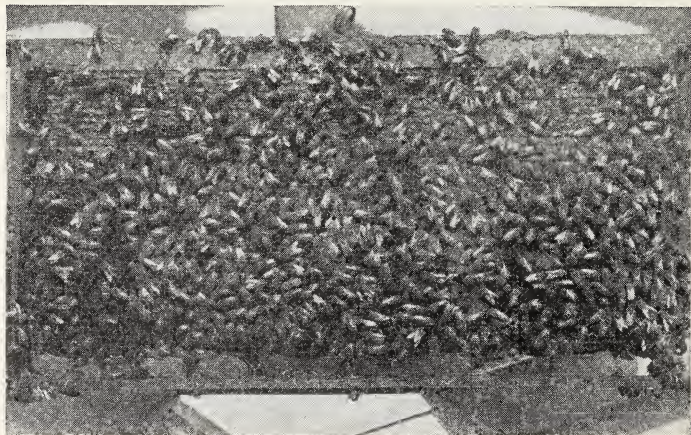


FIG. 1-4. HONEY FRAME FROM A BEEHIVE.

These busy bees have filled the top cells with honey and have capped them.

The Family Life of Honeybees. To understand the ways in which the bees in the hive live and work together as a family, we should first learn about the life history of honeybees. Fig. 1-5 illustrates much of the story. Study the drawings as you read further. Notice that the cells are horizontal. The queen places the egg (A) in the far end of a cell. Three days later, a tiny, legless larva called a *grub* (B) comes from the egg. This larva is fed for three days on a rich milky food called "royal jelly". Then the workers must decide whether the little grub is to become a worker or a queen. If she is to become a queen, they enlarge her cell and continue to feed her "royal jelly". After the third day, worker larvae are fed on beebread, a mixture of honey and pollen. When the larva is about six days old and fully grown (C), the workers cap the cell with wax. The larva within sheds its skin and becomes a motionless *pupa* (D). During the next 12 days many changes take place. What was a legless grub becomes a winged, hairy *adult* bee (E) with three pairs of well-developed legs, a sting, and all the equipment necessary to gather food, make wax, build cells, and store honey. Three weeks after the egg is laid, the worker eats its way out through the wax cap and starts its life of labour.

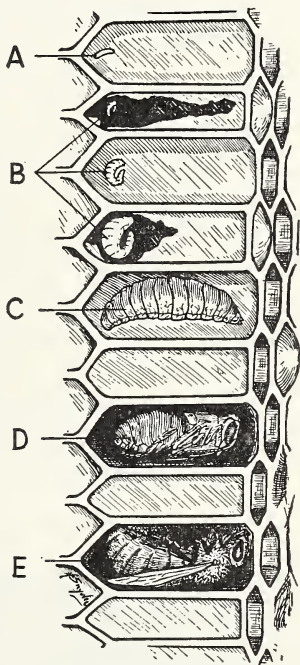


FIG. 1-5. HOW A HONEYBEE GROWS UP.

A, an egg; B, three stages of larvae; C, a full-grown larva; D, a pupa, showing the development of its head, eyes, wings, and legs; E, an adult queen ready to emerge.

The Worker Bees. True to her name, the worker bee toils

unceasingly from the time she comes from her cell until, worn out, she dies. When she emerges from her cell, she immediately begins to feed and take care of her sisters who are still larvae. For about a week, she performs such household duties as feeding the growing larvae, cleaning out the old cells for new eggs, and serving the queen. Then she becomes a porter, taking honey from the field bees, and storing it in the comb. If necessary, she makes wax and builds new comb.

Having served within the hive, the worker bee takes up guard duties. Her large compound eyes and sensitive feelers enable her to detect robber bees and other strange insects. If necessary, she and her fellow guards will kill an intruder.

The workers carry the nectar back to the hive in a special honey stomach. At the hive, the porters receive and store it in the comb cells. Nectar does not become honey until some water has been evaporated from it. To help in this process, there are "ventilator" bees stationed at the mouth of the hive. By moving their four wings rapidly, these bees bring in cool air and force out warm, moist air, thus ventilating the hive and helping to change nectar to honey.

After five or six weeks of unceasing toil, "there comes a time when frayed and broken wings fail to carry the last load home, and the bee dies in the field, unmissed and unmourned by her co-workers."



FIG. 1-6. A HONEYBEE LADEN WITH POLLEN.

Notice the cluster of pollen in the pollen basket on her hind leg.

Now, let us review the special adaptations of the bodies of worker bees for their many tasks. The two pairs of strong, light, membranous wings, attached to the thorax, adapt the workers well for rapid flight, often through long distances,

and for the carrying of heavy loads of pollen or nectar. The three pairs of legs, also attached to the thorax, help the bees in many tasks. Their jointed structure and their claws make it possible for the bees to walk, climb, and crawl about on honeycomb and flowers. A long cavity on each hind leg serves well as a pollen basket.

Like grasshoppers and all other insects, honeybees have a tough exo-skeleton that gives them shape and provides protection. Because the abdomen is divided into segments, it is flexible. It also bears the breathing pores.

Bees' eyes and feelers, all attached to the head, make them aware of their surroundings. By means of the two large, compound eyes, one on each side of the head, bees see in all directions when travelling, but they use their three tiny simple eyes for seeing nearby objects. The two jointed, flexible feelers help the simple eyes in close-up explorations.

The mouths of bees fit them well for their work. Although the jaws are small, they enable the bee to work with pollen and wax. The tongue, in the form of a tube, is long enough to reach into a flower to get nectar.

Test Yourself

1. In what ways do the various kinds of bees in a hive serve the best interests of the bee colony and of man?

2. What tasks do worker bees perform (a) in the hive, (b) out of the hive?

3. Describe the organs that adapt a worker honeybee (a) to fly, (b) to eat nectar, (c) to climb on flowers and honeycomb, (d) to see enemies and where she is going?

4. How does the food of a queen bee differ from that of a worker?

5. Compare the larva or grub of the honeybee with the nymph of the grasshopper in the extent to which it resembles its parents, and in its activity. Into what does each develop?

6. A colony of bees made 10 pounds of honey on a bright June day. Four pounds of nectar are needed to make a pound of honey. If it took a thousand bee trips to gather an ounce of nectar, and each bee made sixteen trips during the day, how many of the worker bees in the colony were gathering nectar?

The Monarch Butterfly

The monarch or emperor butterfly is one of our most showy and most frequently seen insects, especially in the vicinity of milkweed plants. As a butterfly, it illustrates several interesting insect characteristics not found in the life of the grasshopper or the honeybee.

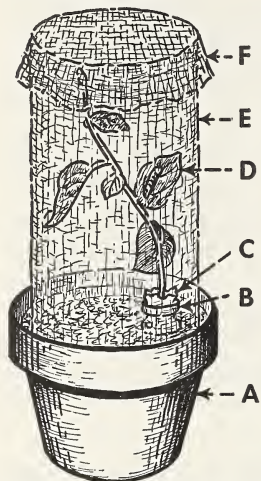


FIG. 1-7. AN INSECT CAGE. A, a flowerpot; B, a small bottle of water in the soil; C, cotton to hold the stem in place; D, a plant with a caterpillar on a leaf; E, wire screen; F, screen cover.

PUPIL INVESTIGATIONS. *If possible, observe the habits of living monarch butterflies in their different stages of development, both in the field and in the classroom.*

1. Visit a clump of milkweed plants early in September. Look for monarch butterflies flitting about among the plants and taking nectar from their flowers. Look for eggs on the underside of the leaves. You may find the striped larvae feeding upon foliage, or even a green chrysalis, studded with a row of golden beads at the top.

2. Collect larvae and place them in a sealer or in an insect cage (fig. 1-7) in the classroom. Feed them milkweed leaves. Watch how these larvae grow and moult. You may see one change to a chrysalis, or a butterfly emerge from a chrysalis.

3. Examine the long, jointed feelers or antennae of a monarch butterfly. Notice that each ends in a long knob.

Life History of the Monarch Butterfly. The female butterfly lays its eggs on the underside of milkweed leaves. These eggs hatch into greenish *larvae*, called *caterpillars*, marked with black and yellow bands. Feeding by day and by night on the leaves of milkweed plants only, the larvae grow rapidly to a length of about two inches in less than two weeks, shedding the skeleton skin each time it becomes too tight. When full-grown, the caterpillar suspends itself with a silken thread from the underside of

a leaf. Then comes the magic change to a smooth, green *pupa*, called a *chrysalis* or a *chrysalid*, ornamented with a row of gold beads near the top and larger gold dots near the base. From this chrysalid, the *adult* butterfly emerges in about two weeks, dries its wings, and soon flies away. Study fig. 1-8.

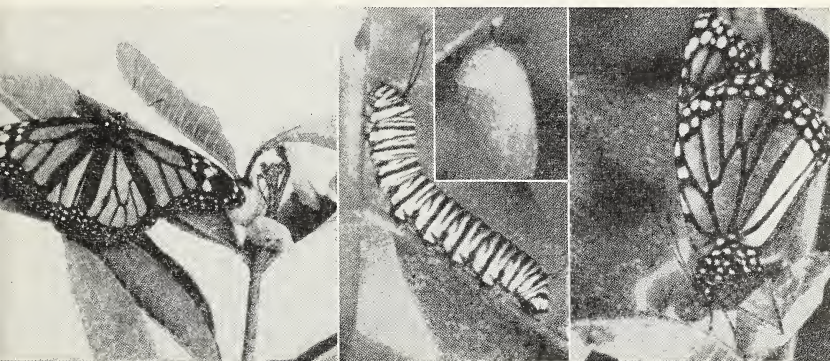


FIG. 1-8. LIFE HISTORY OF A MONARCH BUTTERFLY.

Left, a butterfly laying eggs on the leaves of a milkweed plant; centre, a larva feeding on a milkweed leaf, and a chrysalid hanging from a leaf; right, a butterfly just emerged from the empty chrysalid shown.

Feeding Habits and Adaptations. Adult monarch butterflies feed upon nectar from the flowers of milkweed plants. Like other butterflies, they are well adapted to obtain this by having a tongue (proboscis) long enough to reach deep into the flower and suck up the sweet nectar. When not in use, the tongue is coiled up beneath the butterfly's chin.

As we stated above, the caterpillars eat leaves. For this work, their biting mouth parts, somewhat like those of a grasshopper, adapt them well.

Adaptations for Travel. Adult butterflies usually drift about from plant to plant in a leisurely manner, using their two pairs of large, brightly-coloured wings. When butterflies alight, they fold their wings above their back, with the upper surfaces pressed together. In this habit, they differ from moths, for

moths always lay their wings flat over the back of the body when they are not being used for flight.

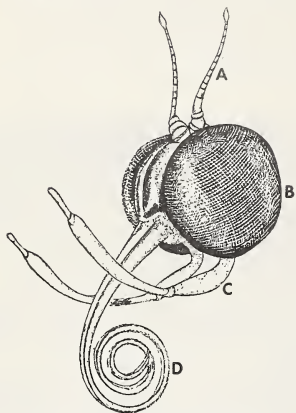


FIG. 1-9. THE HEAD OF A BUTTERFLY.

A, antennae; B, large compound eyes; C, feelers on the mouth; D, the long sucking tube (proboscis), partly uncoiled.

Perhaps you have seen dust on your fingers after handling butterflies or moths, and also noticed that their wings lose their bright colours after being rubbed. Both observations are explained by the fact that a covering of tiny, coloured scales, arranged in perfect rows, gives the wings their colour patterns and, at the same time, protects them.

Both the butterflies and the caterpillars crawl about plants on their three pairs of legs which are attached near the front of the body. In addition to these three pairs of legs with their small, clawed walking feet, caterpillars have four pairs of short, fat “pro-legs” to support the centre part of the body as they walk or rest.

Adaptations for Protection. Fortunately for adult monarch butterflies, the caterpillars, and the chrysalids, no bird likes their taste. The bright colours of all three stages seem to warn birds to beware. Few other insects have this kind of protection.

Monarch butterflies have no need for winter protection, for, like some birds, they migrate far to the south. In autumn the young butterflies, recently emerged from their chrysalids, collect in large flocks and drift southward, visiting blossoms along the route. At night they rest by the hundreds in trees and shrubs, but they are off again early in the morning. How marvellous that they follow a route that they have never seen before!

In spring these same butterflies come northward from their winter homes in the Southern States. When a female locates young milkweed plants along the route, she deposits her eggs

on them. The butterflies of the next generation, developed from these eggs, migrate still farther north. Some of them reach Ontario in July and produce a second generation—the one that will migrate south in autumn.

Review Questions

1. How do the stages in the life history of a monarch butterfly differ from those of a grasshopper? How are they similar to those of a honeybee?

2. How do the adaptations of adult monarch butterflies for feeding differ from those of the caterpillars? How do they differ from those of grasshoppers?

3. Why do the wings of butterflies lose their colour when rubbed?

4. How does each of the following protect the larvae, the chrysalids, and the adult monarch butterflies: taste, colour, migration?

5. How could you distinguish a butterfly from a moth by observing the position of its wings when the insect is resting?



FIG. 1-10. CATERPILLAR AND CHRYSID OF THE BLACK SWALLOWTAIL BUTTERFLY.

Note

In studying the characteristics of butterflies, the black swallowtail butterfly, which is the adult stage of the black-striped, green caterpillars found on carrot, parsley, celery, and parsnip plants, may be substituted for the monarch butterfly. Many of the adaptations described above apply to both, except that the swallowtail does not have a protective taste, does not migrate, and has a brownish angular chrysalis that survives winter.

Water Insects

Some insects spend a part or all of their lives in ponds and streams. These have special structures and habits that adapt them to live in water. First-hand observations of their special adaptations may be made by rearing some water insects in an aquarium indoors.

PUPIL INVESTIGATIONS. *Prepare an insect aquarium in your class-room.*

1. As a guide, use the detailed drawings and directions for setting up an aquarium, as given in *General Science*, Book 1, pages 416-417. Pond water is best for water insects. Arrange the sand and a few water plants, then add the water.

2. Have a hike to collect water insects in a nearby marsh or pond. Take along a kitchen strainer and some tin cans. Skim off a few water striders as they dart here and there on the surface of the water, or some whirligig beetles as they circle about. Dip deep into the mud at the bottom of the water and pull up some decaying submerged leaves with which you may find dragonfly nymphs, caddis worms, and water beetles.

Keep your catch in several containers. When you return to the class-room, place a few of the water insects in your prepared aquarium, and leave the others in your vessels of pond mud and water.

Use the illustrations in fig. 1-11 to help you recognize the insects you find, then watch for the adaptations mentioned below.

Whirligig beetles are easily recognized as they circle round and round each other on the water. Their oar-like hind legs, fringed with hairs, propel their canoe-shaped bodies forwards. Their eyes can see downwards into the water and upwards from it at the same time.

Diving beetles are black or brown in colour and vary widely in size. They hang head-downwards among water plants, always watching for larvae or other water insects for food.

Water striders are found in still pools skimming rapidly on the surface of the water on slender, spider-like legs. When they dive from danger, they take a film of air into the water with them for breathing.

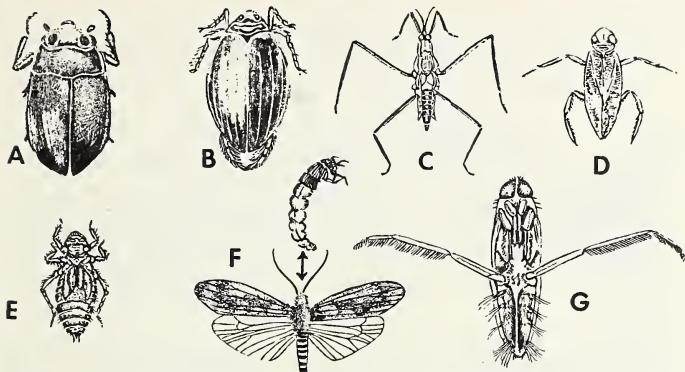


FIG. 1-11. SOME WATER INSECTS.

A, whirligig beetle; B, diving beetle; C, water strider; D, water boatman; E, dragonfly nymph; F, caddis fly adult and larva; G, back swimmer.

Water boatmen stay down in the water for much of the time. For this reason, they must take air down with them for breathing. This air forms a glistening blanket over their bodies and makes the insects so light that they must hold themselves down by means of their claws. Their flattened hind legs are well adapted for swimming, and their wings enable them to fly to another stream if theirs dries up.

Dragonfly nymphs live among water plants or rubbish in water. There they wait in ambush to grasp other water insects, especially mosquito wrigglers, in their huge, powerful lower lips. To breathe, they draw water into the body, take oxygen from it, and expel the water again, pushing themselves along as they do so.

Caddis worms will look like bits of rubbish walking at the bottom of your aquarium, for they build homes of tiny sticks, sand, and other pond refuse. These homes they carry with them, reaching out a little way to crawl along. The adult is a moth-like caddis fly, often attracted to outdoor lights at night.

Back swimmers swim on their boat-shaped backs, propelled by their broad hind legs. If disturbed, they dive into the water, taking a bubble of air with them for breathing.

Note

The mosquito will be studied in chapter 5 when we consider some other insects.

General Adaptations of Insects

While studying the grasshopper, the honeybee, the monarch butterfly, and some water insects, we have discovered that insects are well adapted to live in whatever surroundings Nature has placed them. Now let us review the adaptations of insects in general.

Structure of Insects. All insects are enclosed by a more or less tough outer skin or skeleton, called an exo-skeleton. Because this is usually too tough to stretch, it must be shed occasionally if growth is to take place. The new skin, already formed under the old one, is sufficiently soft and elastic to stretch for a little while. The exo-skeleton is divided into three parts, the *head*, the *thorax*, and the *abdomen*. The jointed or segmented nature of the exo-skeleton makes the body flexible.

The head of an insect bears the eyes, the mouth, and one pair of feelers (*antennae*), used for feeling and, in some insects, for smelling and hearing. The feelers of butterflies end in knobs, but those of moths are always feathery. The thorax bears the wings and legs; the abdomen contains the breathing pores and the egg-laying apparatus.

Life Histories of Insects. Nearly all insects reproduce by laying eggs. The eggs hatch into *larvae* or into *nymphs*. Nymphs change directly into *adults*, but larvae must change to *pupae* before becoming adults. Larvae and nymphs are usually active, and most feeding and growth, accompanied by moulting, takes place in these stages. Larvae may be called *caterpillars* (of moths and butterflies), *maggots* (of flies), or *grubs* (of bees).

Most pupae do not move around, with the exception of those of mosquitoes. However, wonderful changes do take place within them during this stage: wings develop, legs form or become changed, and feelers and mouth parts often become modified.

Some pupae have special names, such as the *chrysalid* of butterflies; other pupae, such as those of moths, are enclosed in and protected by a silken *cocoon*.

Butterflies, honeybees, house flies, and other insects that change through all four stages — egg, larva, pupa, and adult—during their life histories are said to make a complete change or to undergo a *complete metamorphosis* (metamorphosis —

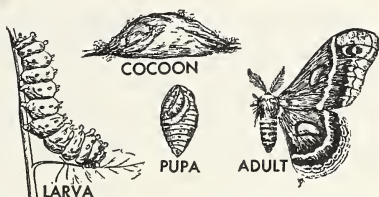


FIG. 1-12. THREE STAGES IN THE LIFE HISTORY OF THE CECROPIA MOTH. A moth has feathery antennae. Its pupa is protected in a cocoon.

change of form). Insects, like the grasshopper, that change through only three stages—egg, nymph, and adult—and show little change in form from the time of hatching from the egg, are said to undergo an *incomplete metamorphosis*.

Feeding. In insects that eat vegetation, such as the grasshopper and potato beetle, the mouth is provided with jaws well adapted to bite and chew. Insects that take in liquid food have long sucking tubes. The mouth parts of mosquitoes are adapted to pierce the skin to obtain blood, and the long sucking tubes of butterflies can be coiled up under the chin when not in use.

Seeing. Because insects have two large compound eyes, each made up of many immovable small parts, they can see forwards, sideways, backwards, and upwards. Their tiny simple eyes, usually three in number, distinguish light from darkness and see for short distances.

Travelling. Most insects have two pairs of wings; flies and mosquitoes have only one pair; and a few insects have none. Insect wings vary greatly in size and appearance, but all consist of veins covered with a membrane. Bees, butterflies, and some other insects use all wings for flight; grasshoppers and beetles have hard front wings that serve as protective covers for the back flying wings. A house fly can beat its wings three hundred

times a second, causing a humming sound. All insects have three pairs of legs. The feet usually end in small claws and, sometimes, have soft pads that stick to smooth surfaces.

Breathing. Insects breathe through tiny openings, called *spiracles*, along the sides of the body. Air for breathing passes through these into tubes which distribute the air throughout the body. Water insects have special devices by means of which they get air at the surface of the water or take air bubbles down into the water with them.

Things To Do

1. Fit a glass lid to a chalk box. Collect woolly bear caterpillars, put them in the prepared box, and watch them spin their cocoons.

2. Collect cocoons of such moths as the *Cecropia* and *Polyphemus* in autumn. Keep them in a cool place over winter and bring them into the warm classroom in spring. You may see a moth work its way out of its cocoon and stretch out its crumpled wings.

3. Rule a large table on the blackboard with vertical columns headed *Feeding* and *Mouth Parts*, *Life History*, and *Locomotion*. In a column at the left insert the names of several common insects and, after each, under the proper headings, summarize the main facts that describe its ways of living.

Your Word List

Adaptations, exo-skeleton, thorax, abdomen, segments, nymph, moult, larva, pupa, chrysalid, cocoon, maggot, complete metamorphosis.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Butterflies and Moths", Vol. B, pp. 364-370; "The Amazing World of Insects", "Insect Collecting and Mounting as a Hobby", Vol. IJ, pp. 152-161; "The Grasshopper", Vol. GH, pp. 167-170; "In the Busy Workshop of the Bees", Vol. B, pp. 93-100; "Protective Coloration", Vol. P, pp. 419-422.

16 mm. Sound Films

Ontario Visual Education Branch

Monarch Butterfly (colour) (SN-50)

Butterflies (SN-20)

Grasshoppers (SN-34)

The Honeybee (SN-39)

Pond Insects (SN-63)

Ontario Department of Lands and Forests

Living Flowers (life cycle of the butterfly)

City of Wax (life history of honeybee)

Film Strips

National Film Board of Canada

The Grasshopper

Ryerson Film Service

Growing Up of the Monarch Butterfly

2

MAMMALS AND BIRDS HAVE THEIR SPECIAL ADAPTATIONS

Mammals

The Cat as a Domestic Animal. The cat is one of the most common and popular pets. We appreciate it for its good company, its comfort-loving habits, its cleanliness, and the ease with which it adapts itself to varying environments. A cat seems to understand our voices and our actions and soon learns to let us know when it is hungry and when it wants to come in or out. On the other hand, a cat can express other feelings equally well. It shows anger by bending its ears back and whipping its tail from side to side. When it is frightened, its hair, especially that of the tail, stands on end. Its savage howl warns us when it is in a fighting mood. Few pets are as cleanly in their habits or take such pride in keeping their fur spotless.

PUPIL INVESTIGATIONS. *Some habits of cats.*

1. Carefully observe a pet cat from time to time and try to answer these questions. Can a cat understand the actions and tones of voice of people? Give evidence to support your answer. How does a cat make its wishes known to people? How does it show when it is afraid? Comfortable? Satisfied? Angry?

2. Observe how a cat runs, jumps, climbs, stalks its prey, and

catches and kills its prey. Examine a cat's feet to discover how its toe-pads and claws are adapted for these activities.

3. Observe how a cat uses its teeth when eating. Examine the long side teeth, the small front teeth, and the back teeth of a cat to determine how they are adapted for the work they do.

4. Observe the shape of the pupil of a cat's eye in bright light, then immediately afterwards in darkness.

5. Test a cat's senses of smell, hearing, sight, and feeling. Observe how it uses its whiskers when passing through narrow spaces.

6. Observe and make a list of evidences of a cat's cleanly habits.

Food and Feeding Habits of Cats. Like its wild ancestors, a cat is chiefly a meat-eater, although it will also eat table scraps and lap up milk. It is well adapted to catch mice, birds, and other living prey. When it has detected a mouse or a bird, the cat steals its way quietly towards it, lies flat on the ground, then, at a well-timed moment, uses all four feet to throw its whole weight on the unsuspecting victim. Quickly, the cat grasps its prey with its claws and sinks its long, sharp teeth into the throat of the victim to kill it.

A cat's feet adapt it well for stalking and catching prey. Its soft walking pads enable it to creep stealthily towards its prey without being heard. Its hind legs are so powerful that it can jump a distance of at least five or six feet to pounce upon prey. The curved claws are always sharp, for they are kept safely sheathed between the soft pads when walking and when otherwise not needed, but it takes only an instant for them to come out and be used to advantage.

A cat's teeth and tongue fit it well to kill living prey and to eat meat. Four long, sharp teeth, called *canine teeth*, two near the front on both the upper and lower jaws, are used to seize the living animal. The cat's ability to open its mouth very wide and the bare spaces behind the canine teeth combine to enable these sharp teeth to pass each other freely and pierce the prey both to kill it and to carry it. Six tiny front teeth, called *incisors*, on both the upper and lower jaws, serve well for scraping meat from bones. Several back teeth, called *molars*, have sharp edges suitable for cutting meat fine enough to be swallowed. Frequently, a

cat may be observed twisting its head from one position to another when using these molars to cut tough meat or muscle. The rough surface of the tongue is used to rasp juices from meat.

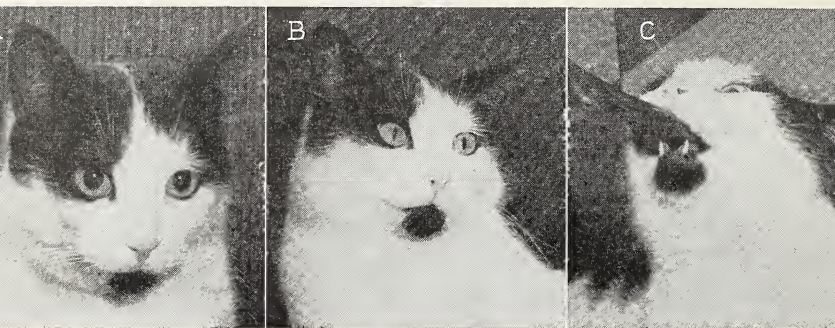


FIG. 2-1. SOME ADAPTATIONS OF A CAT.

A, photograph taken in dim light, showing the pupils of the eyes large and round; B, photograph taken in bright light, showing the pupils as narrow slits; C, large canine teeth being used to grasp a piece of liver.

Notice also: the long, white feelers and eyebrows; the shape and direction of the ears, and the sensitive hairs in them; the hairless entrance to the nostrils; and the fine, soft, insulating covering of fur.

Adaptive Senses of Cats. The keen senses of a cat serve it well. Its ability to see clearly in dim light helps it to spot its prey when hunting at night. Perhaps you have noticed that the pupil in a cat's eye, the opening through which it sees, is a narrow vertical slit in bright light, but covers almost the entire surface of the eye in dim light or darkness. See fig. 2-1, A and B.

A cat's keen sense of smell, by its bare, moist nose, lets it know whether some strange creature is or has been near. The keen sense of hearing possessed by a cat is made possible by such adaptations as the half-cone shape of its ears, the forward and outward direction in which they face, their movability, and the sensitive hairs within them. The ability of a cat to crawl through narrow spaces and close to all sorts of objects without disturbing them or injuring itself is provided by the long sensitive hairs, called whiskers, extending out from the sides of its mouth.

These keen senses, coupled with the ability of a cat to jump from danger, run speedily for short distances, climb trees or posts, and, if necessary, fight with teeth and claws, protect the cat well from any enemy.

Breathing. Like all living things, cats must breathe. The main breathing organs are the nostrils, the breathing tubes which lead to the lungs, and the lungs themselves.

The Dog. NOTE: If the dog is chosen for study in preference to the cat, the following special habits and adaptations should be considered.

A dog chases and runs down its prey rather than stalking it as a cat does. For this activity, it is well adapted by having long, muscular, strong legs and sturdy feet. The heavy pads and strong, though dull, claws of its feet protect them from injury

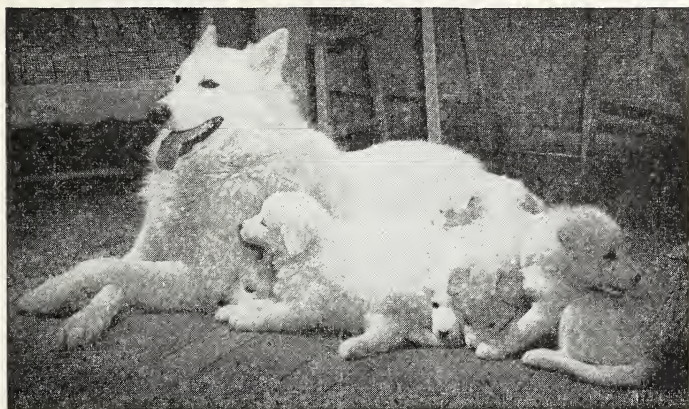


FIG. 2-2. "NANDLA", A SAMOYED DOG AND FAMILY OF SIX PUPS.

The ancestors of these dogs were guards, companions, and sled-drawers of wandering herdsman who, long ago, roamed through forests and cold, barren tundra and migrated from Persia to Siberia. Examine the photograph for the following adaptations of these dogs: the strong, blunt claws that are always out ready for use; the warm body covering, consisting of an undercoat of soft wool and an outercoat of coarser hair; the strong teeth and large tongue, adapted for eating meat; the large openings of the nostrils; the alert eyes and ears, and the intelligent, companionable expression in the face.

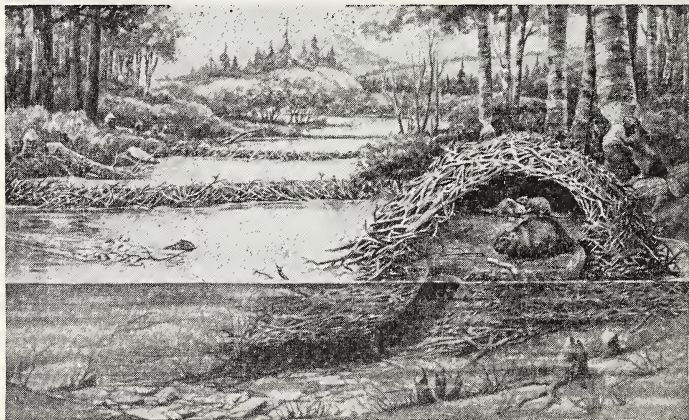
while the dog is running. The claws, never drawn in like those of a cat, are also useful for digging out burrowing animals such as groundhogs. In addition to running, a dog can walk, trot, or bound.

A dog's teeth fit it well for getting food. To seize, hold, kill, and tear the flesh of prey, a dog uses its long and powerful canine teeth. To cut meat into pieces small enough to be swallowed and digested, it uses its sharp, biting molars.

A dog's very keen sense of smell, always used when running, is most useful when the dog is scenting the tracks of animals.

The Beaver, a Mammal Adapted To Live in and near Water. Beavers are found in and near lakes and streams. Although the clearing of the land drove beavers to the more secluded northerly parts of Canada, many of them have become re-established in partially settled areas.

The Beaver's Home Life. The beaver's natural home is in a pond or in a bank beside a stream. If the stream does not provide a natural pond of suitable size, the beaver family builds a dam



(Compton's Pictured Encyclopedia)

FIG. 2-3. A BEAVER FAMILY AT HOME.

Find these: three beaver dams, four beaver ponds, the two levels of living quarters in the beaver home, the entrance to the home from under water, the beaver cutting down a tree, and the beaver swimming and dragging brush towards its home for food.

to enlarge the pond or to create a new one. As a site for a dam, beavers choose a narrow and rather shallow place in a creek or small river. Farther upstream, they gnaw down some small trees, usually birch or poplar. Branches are cut from these and floated or dragged downstream to the site of the dam. Combined with roots, sod, mud, and stones, the branches are gradually woven into a tangled mesh that holds back most of the water, but lets enough seep through to keep the water in the pond fresh.

When the pond is deep enough, the beavers build their house or lodge in it. This consists of a broad foundation of sticks, brush, and mud extending a little above water level, and a dome-shaped roof which leaves space for living quarters above the water. Entrances to the lodge are under water, but an air-hole is usually made through the roof. Comfortable living quarters are arranged in the lodge above the water level.

The beaver family cuts trees and branches of poplar, birch, and willow to provide bark, twigs, and wood for food throughout the winter. The supply is stored in the water where it will be available beneath the ice and not far from the entrance to their lodge.

In spring, two to five baby beavers are born. These are nourished on milk from the mother for about six weeks, and they remain with the family for a year or so.

Adaptations of the Beaver. Beavers have survived because they are well adapted to cut down trees, transport logs and branches, swim, keep warm in cold water, build dams and homes, climb, dig in banks of streams, and protect themselves from enemies. To cut down trees and remove branches, they use their strong chisel-like, self-sharpening front teeth. To transport building materials and food, they must swim. They propel themselves by means of their large, webbed hind feet, and use the fleshy, flattened, scaly tail as a rudder and scull.

In cold water, the thick, water-resisting fur of beavers keeps the skin dry and the body warm. For digging in mud or stream banks, climbing, carrying or pushing logs and branches, and building their dams and homes, beavers skilfully control their

small, hand-like front feet. The nocturnal habits and dark brown colour of beavers help them to avoid recognition by their enemies. When discovered by wolves or man, they warn other beavers by slapping the flat tail on the water, then protect themselves by escaping into the water, into their homes, or into holes in the banks of streams. If necessary, beavers will fight ferociously.

Some Special Adaptations of Mammals. Any kind of mammal has to be able to obtain sufficient food and to protect itself from its enemies if it is to survive. We have just learned how a few mammals succeed in solving these problems. The following table should convince us that mammals in general are well equipped with special adaptations to solve most of their problems of living.

Mammals Classified by Their Habits and Adaptations

Classification and Examples	Habits	Adaptations
<i>Flesh-eating or Carnivorous Mammals:</i> Cat family, dog family, weasel, mink, marten, fisher, skunk, otter, raccoon, bear, seal	Eat flesh of other animals: smaller or defenceless mammals, birds, insects, fish, etc.; stalk or run down prey, then seize it with their claws and teeth	Legs and feet adapted for running and pouncing; claws well developed; canine teeth long, strong, and pointed, adapted to grasp, hold, and kill prey and to pierce tough hides; incisor teeth (front) weak, but useful for biting, tearing, and scraping flesh; cheek teeth (molars) sharp-edged, like shears, adapted for cutting flesh and bone into small pieces; little chewing done, for flesh is easily digested
Wildcat, Canada lynx	Nocturnal; eat rabbits, cottontails, and birds; fight	Adaptations similar to those of the domestic cat
Weasel, marten, otter, fisher, skunk, mink	Frequently nocturnal; eat fish and other small animals chiefly; protect themselves by escape and fighting	Adaptations as above; mink and skunk give off an offensive odour

Mammals Classified by Their Habits and Adaptations

Classification and Examples	Habits	Adaptations
<i>Flesh-eating or Carnivorous Mammals (cont'd)</i> Dog, wolf, fox, coyote	Hunt in packs; travel fast and for long distances; eat flesh	Can protect themselves by speed, cunning, and fighting
Raccoon, bear	Eat vegetable food in addition to flesh and fish	Teeth less well fitted for flesh eating, but better for chewing; protection obtained by living in caves or holes
Seal	Lives in water most of the time; eats fish	Hind legs serve as a rudder; kept warm by a soft undercoat of fur
<i>Insect-eating Mammals:</i> Mole	Eats insects from the ground chiefly	Front feet broad and shovel-like for digging and burrowing
Bat	Can fly; nocturnal; has a keen sense of hearing and of feeling; eats insects	Front limbs covered with webs of skin to form wings; claws enable it to hang; many sharp teeth hold and chew insects
<i>Hoofed Mammals:</i> Cattle, sheep, goat, antelope, and mammals listed below	Eat vegetable foods; are preyed upon by flesh-eating mammals; many travel long distances to new feeding grounds, and move rapidly to escape from enemies; most hoofed mammals, except horses, chew cud	Front teeth adapted for biting off grass; molar teeth have a flattened grinding surface; most are cud-chewers, i.e., they store food temporarily in a special stomach, then return it to the mouth to be chewed as cud; hoofed mammals travel on the tips of the toes for speed; toes end in hoofs, but have no claws
Horse	Lives and feeds on plains and pastures	Long legs and one-toed hoofs increase running speed

Mammals Classified by Their Habits and Adaptations

Classification and Examples	Habits	Adaptations
<i>Hoofed Mammals (cont'd)</i>		
Pig	Food widely varied	Large canine teeth; nose adapted for rooting in soil
Camel	Travels long distances on desert soil; lives on leaves of trees and dry vegetables	Carries reserve food supply in the "hump" on its back; two toes and a pad on each foot give support on soft soil
Deer, moose, elk	Browse vegetation; use their antlers to fight	Antlers shed each year at the base, then new ones grow; spots on fawns make them less conspicuous under trees
Giraffe	Eats foliage from branches of trees	Its long front legs and neck enable it to reach its food
<i>Gnawing Mammals (Rodents):</i>		
Squirrels, chipmunk, gopher, woodchuck, beaver; rats, mice; porcupine, guinea pig; rabbits, hares	Entirely vegetarian. eating green vegetation, bark, seeds, grain, etc.; gnaw off food, then grind it before swallowing; most species live in homes of some sort; obtain protection by burrows, escape, fighting, colour	Gnawing teeth (incisors) curved, chisel-like, and self-sharpening as their ends rub together; teeth grow continually from their roots as their crowns wear down; most species well adapted for running, some for climbing; hares protected by white colour in winter, and porcupines by their quills
<i>Other Mammals:</i>		
Whale	Lives in water; swims; comes to the surface to "spout" air from its lungs and breathe in fresh air; eats fish	Large tail fin for propelling in water; steers with modified front limbs called flippers; nostrils open as a "blowhole" for breathing; body insulated from the cold of the water by a thick layer of fat (blubber)
Elephant	Eats vegetable food	Stout, straight limbs, ending in a broad, padded foot, well adapted to support a great weight; trunk to reach distant food, also air when swimming; elongated teeth, called tusks, made of ivory, used to dig up roots



FIG. 2-4. SOME WELL-ADAPTED MAMMALS.

Left column, flesh-eating mammals: (reading downwards) notice the hand-like foot of the raccoon, the lithe body of the weasel, the strong claws of the bear, and the flippers of the seal, well adapted for swimming.

Top middle, insect-eating mammals: notice the shovel-like foot and sensitive feeling hairs of the mole, also the wings, claws, and ears of the bat.

Centre, a beaver: find these—its flat tail and webbed hind feet, the beaver house, the sharp stump, and the pile of beaver food (branches of trees).

Bottom middle, an elephant: notice the long trunk, sharp tusks, and large, flat feet.

Right column, hoofed mammals: (reading downwards) notice the one-toed hoof of the horse, the long neck and legs and the hoof of the giraffe, the two-toed hoofs of the mountain goat, and the large feet of the humped camel.

Characteristics of Mammals. See chapter 4.

Birds

Adaptations of the Hen. The domestic hen still retains the characteristics of the jungle fowl from which it has been developed.

PUPIL INVESTIGATIONS. *How do a hen's physical characteristics adapt it for its ways of living?*

1. *Getting food and drink.* What does a hen usually eat? Where does a hen find these foods? How does a hen remove refuse and soil to get at grain and insects? How are her toes and claws fitted for their work? How does a hen pick up food? Does she chew it? Watch her drink.

2. *Perching.* How are a hen's toes arranged to hold her on a perch?

3. *Senses.* Can a hen see you with both eyes at once? Look carefully for any evidence of eyelids. Test the hearing power of a hen. Look on the sides of her head for ear openings.

4. *Breathing.* Find the openings to the nostrils near the base of the beak.

Adaptations for Getting Food. Many of the adaptations of hens, as of other birds, are connected with finding, getting, and using food. Although we may feed hens a variety of commercial feeds, their natural food consists chiefly of seeds and insects found on or in the soil, often among growing plants or covered by their remains. To detect food in these places, hens must search, first with one eye, then with the other, for they cannot see the same spot with both eyes at once. To uncover more seeds and insects, hens scratch away the debris and dig into the soil. For this work, their long, strong, stubby and slightly curved claws adapt them well. Instead of scratching, hens may use their sharp, horny beaks to peck into the ground. To pick up the food, hens use their two mandibles, acting as fingers or pincers. All food is swallowed whole, to be softened and ground up later by grit and gravel in the muscular gizzard. Hens have no need, therefore, for teeth.

Protective Adaptations. Although man's care of hens leaves them with less need than other birds for protection, they have inherited from their wild ancestors many protective habits and structures. While searching for food among vegetation, hens are partly hidden from hawks, foxes, and other enemies, yet they remain watchful. Although the two eyes, one on either side of the head, are immovable, the birds can see in all directions. If it is necessary to escape, hens can run swiftly, using their strong toes and claws as we would use spikes or cleats on shoes to get a firm foothold. In an emergency, they can fly.

While hens are scratching or running among plants and vegetable remains, their legs and feet are well protected by their covering of horny scales.

When perching, hens are held securely in place by having three toes around the front of the perch, and the fourth toe wrapped around the back of it. This adaptation applies to all perching birds, such as robins, bluebirds, meadowlarks, warblers, and sparrows.

The habit of dusting themselves in dry soil helps hens and other birds to keep themselves free from mites and lice.

Adaptations for Breathing. Like all other birds, hens breathe with nostrils and lungs. The openings of the nostrils are easily seen in the upper side of the beak, near its base. The efficient breathing system of birds enables them to maintain the very high body temperature characteristic of the feathered folk, and supplies them with the large amount of energy required for flying.

The House (English) Sparrow.

An Investigation and Writing Activity for Pupils. Observe the habits and adaptations of house sparrows around home or at school. Use the suggestions given for pupil investigations and the information given in the text concerning hens as a guide. Then write several paragraphs on house sparrows, using headings similar to those used above for hens.

How Birds Are Adapted To Fly and Live in the Air. Man has only recently learned the secret of flight, but flying has always been the natural mode of travel for most birds. Some of the

problems that man has had to solve in order to fly are: (1) how to construct a machine that will remain up in the air; (2) how to make such a machine move forwards when in the air; (3) how to keep himself warm when at high altitudes. Birds are able to solve all these problems.

The first problem of flying is to stay up in the air. You know that water will hold up a light object such as a piece of wood, but that you are likely to sink in water unless you exert yourself strenuously by swimming or by treading water. In either case, you press down on the water with each stroke of hand or foot. This downward pressure keeps you from sinking into the water. Air acts somewhat like water. If you hold an open umbrella above you and jump from a step, you will feel the air holding you up as it presses against the underside of the downward-moving umbrella. In a similar manner, air holds birds up in the air. Let us find out how.

Wings Help Birds To Stay Up in the Air.

PUPIL INVESTIGATIONS. *How do wings help birds to fly?*

Bring a hen or a pigeon to the classroom. Hold it upright by the body or the feet. Notice its weight. What difference do you feel when the bird strokes its wings downwards? Why did the body lift? In what other direction did it move? What is the value of the large size of the wings? Feel the air rushing out from under the wings as they are stroked downwards. It is this air that lifts the body as the wings are lowered. The more air the wings can strike, the more lifting and propelling power they will have. How does the shape of the wings help them to catch more air on the downward than on the upward stroke?

When a bird is flying, its wings are lifted well above the back, then they are both lowered with a strong stroke downwards and backwards. The hollowed-out underside of the wings enables them to get a good grip on the air against which they push. In this manner, the bird pushes itself upwards and forwards by pressing quickly on the air beneath it. When the wings have reached the lowest point in the stroke, they are very quickly lifted upwards and forwards to their original positions, ready for another downward stroke.

The wings of birds are well fitted to help them fly. Like the oars of a boat, they have a large surface, but little weight. The quill feathers on the wings give them this large surface.

Both the quill feathers and the wings are strong. The wings are also controlled by large muscles, known to us as the breast meat of a fowl.

PUPIL INVESTIGATIONS. 1. *How are quill feathers adapted for their work.*

Carefully examine a quill feather. Notice how light it is. Bend it back and forth to discover how strong and flexible it is. The *shaft* (fig. 2-5) forms its strong framework. Move a quill feather rapidly back and forth through the air. Notice how its flat part, the *vane*, catches much air.

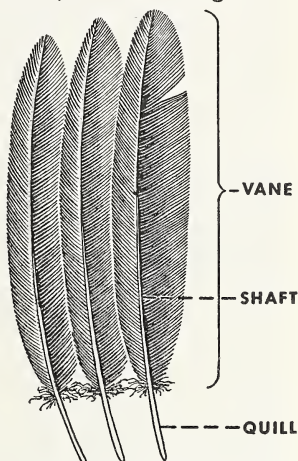


FIG. 2-5. QUILL FEATHERS.
The hollow quill and the central shaft give strength; the vane, a large surface area; and the fine, downy feathers, warmth.

2. *How does the arrangement of the quill feathers on a wing prevent air from passing between them on the downward stroke of the wing?*

Observe how the quill feathers on a wing overlap (figs. 2-5 and 2-6). Notice that each quill feather presses close against the next one when the wing is lowered. This gives the wing an air-proof surface that presses upon all the air beneath it without letting any pass through it. Now, observe how the quill feathers separate when the wing is raised. This lets the air pass through between them on the upward stroke. Why, then, does the upward stroke of the wings not force the bird back down just as the downward stroke forces it upwards?

These investigations show us how both the structure and the arrangement of the quill feathers on a bird's wing help it to fly. The shaft of each quill feather gives it strength; the vane gives it large surface; both give it strength. The concave under surface

of the wing and the overlapping arrangement of the quill feathers cause the wing to get a good grip against the air on the downward stroke. As the wings are lifted again, the air either slides off the rounded upper surface or sifts between the quill feathers with little resistance, preventing the bird from being pushed back down again.

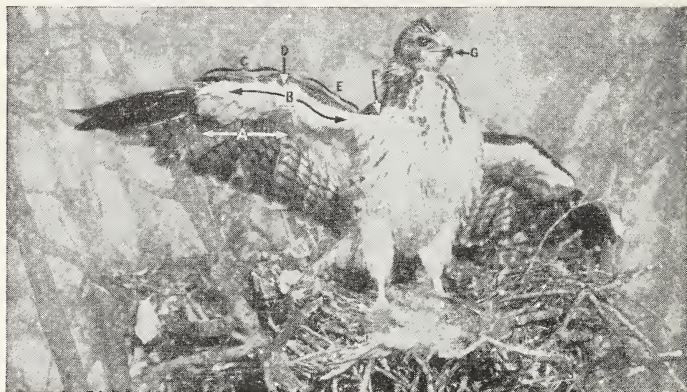


FIG. 2-6. A YOUNG MARSH HAWK ON ITS NEST.

A, quill feathers; B, wing coverts; C, hand; D, wrist; E, fore-arm; F, elbow; G, beak.

To see how the bird's wing resembles your arm, hold your right elbow close to your body, then stretch out the fore-arm and hand as the hawk has. The soft wing coverts provide warmth.

Wings Help Birds To Propel Themselves Forwards. We have seen that each downward stroke of a bird's wings is directed partly backwards. This backward push against the air gives the bird's body a push forwards. Between strokes, the bird just continues to coast smoothly forwards.

The Body Feathers Help Birds When in the Air. The covering of feathers makes it easier for a bird to fly. This layer increases the size of the bird considerably, but adds little to its weight. Thus, by making the bird much lighter in proportion to its size, the feathers help it to stay up in the air.

The feathers fill out the hollows around the neck and



FIG. 2-7. YOUNG MARSH HAWKS AND HAWK'S EGGS.

Are the birds hungry, angry, afraid—or just noisy? Notice the soft, downy feathers that cover these newly hatched birds, also the developing quill feathers on the bird at the left.

shoulders of a bird, giving its body a smooth, double-pointed, streamlined form, somewhat like that of a speed boat or a racing car. In this manner, the body feathers help the bird to move through the air with little resistance.

Other Adaptations of Birds for Flight. The bony framework of a bird is very light, but strong. This is because some of the bones are hollow while others are flat and thin. The large surfaces of the breast bone of a bird are well adapted to hold the large wing muscles which enable the bird to fly. We have already mentioned the values of the very efficient breathing system of birds.

Special Adaptations of the Downy Woodpecker. A downy woodpecker lives chiefly on insects and their larvae found in the wood or the bark of trees. For this reason, we usually see this bird climbing jerkily upwards on the trunks of trees in our gardens, orchards, or woods. To obtain a larva from under the bark, the woodpecker brings all his equipment into play. He grasps the bark, pincer-like, with the claws of all four toes, two pointing backwards and two forwards, then places his tail against the tree as a stiff prop. When firmly set, he strikes a series of hard blows with his powerful, sharp bill, gradually drilling a

hole into the wood until he reaches the tunnel of the larva. To pull out the larva, the woodpecker extends his tongue into the hole and inserts its hard, sharp tip into the prey. Equipped with backward pointing barbs, the tongue easily extracts the victim.

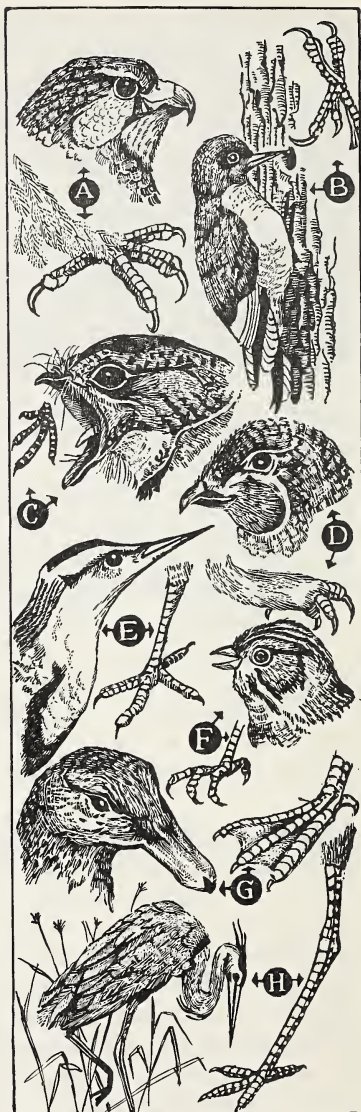
Adaptations of Different Birds to Different Environments. Like the hen and the downy woodpecker, each kind of bird has its particular way of living. Its food, its habitat, its activities, and the nature of its bill and feet all seem to fit into one pattern.

The table entitled "How Birds Are Equipped To Secure Food" shows how birds may be arranged in groups according to their food and their special adaptations for obtaining it.

FIG. 2-8. HOW BIRDS ARE ADAPTED BY FEET AND BILLS TO OBTAIN THEIR FOOD.

Examine and discuss in class the many details shown in this drawing, and study the table opposite at the same time.

A, a hawk; B, a woodpecker on a tree trunk; C, a flycatcher; D, a quail; E, a meadowlark; F, a sparrow; G, a duck; H, a heron.



How Birds Are Equipped To Secure Food.

(Letters A, B, C, etc., refer to fig. 2-8, opposite.)

Types of Birds	Feeding Habits	Special Adaptations
A. <i>Birds of Prey:</i> hawks, owls, eagles, vultures	Food: mice, rats, rabbits; prey seized, carried, and held by feet	Legs strong; toes long, curved, strong, three forwards and one backwards; claws strong, curved, sharp; bill short, strong, with hooked upper mandible
B. <i>Birds Feeding on Insects from Tree Trunks:</i> flickers, wood- peckers, sap- suckers	Food: larvae and bor- ing insects under bark; perch against side of a tree, sup- ported by the feet and tail; peck holes in the tree and extract insects with tongue	Toes, two forwards and two backwards; claws small, sharp, curved; bill strong, straight, chisel-shaped; tail a stiff prop; tongue long, slen- der, barbed
C. <i>Birds Catching Insects in the Air:</i> swallows, kingbirds, nighthawks, flycatchers	Catch flies, mosqui- toes, and other insects while in flight; mouth snaps shut quickly	Mouth very wide, short, split far back, and sometimes equip- ped with bristles on the sides; bill and feet small and weak
D. <i>Scratching Birds:</i> hen, quail, grouse	Food: seeds, grain, some insects; scratch for food	Toes short and claws strong, short, and blunt; back toe ele- vated; bill usually short; up- per bill slightly longer to pick up seeds
E. <i>Birds Getting a Living from the Ground:</i> robins, meadowlarks, blackbirds	Food: worms, grubs, ground insects, lar- vae, fruit; use the bill to dig in the ground or into fruit	Bill fairly long and pointed; perching feet with three toes forwards and one backwards
F. <i>Seed-eating Birds:</i> spar- rows, snow- birds, gold- finches	Food: seeds, grain; pick seeds from the ground or plants	Bill short, blunt, often strong enough to crush seeds; feet adapted for perching
G. <i>Swimming Birds:</i> geese, ducks, gulls, loons, swans	Food: fish, larvae, worms; take food into the mouth with water, then strain out the water	Three front toes long and fully webbed; back toe small; bill long, blunt, broad, scoop-like, often with toothed, strainer- like edges
H. <i>Wading Birds:</i> herons, bitterns	Food, fish, frogs; dart the head into the water and seize prey	Legs long and bare; toes long and well spread; neck and bill long

Migration of Birds. With each change of season, we notice changes in the kinds and the numbers of birds round about us. Birds such as chickadees, nuthatches, and woodpeckers that are with us all through the year are called *permanent residents*. Other birds that reside permanently in at least some parts of Canada are blue jays, starlings, goldfinches, screech owls, pheasants, quail, and ruffed grouse. Many other birds have formed the habit of journeying back and forth between their northern breeding homes and their southern winter homes. These *migratory birds* are of two groups, those that breed in the far north and spend only the winter with us (winter residents), and those that spend the winter in the south and the summer with us (summer residents).

Important among our winter residents are snow buntings (snowflake birds), slate-coloured juncos, brown creepers, and tree sparrows. Snow buntings are commonly seen in flocks in open fields, feeding on weed seeds above the snow. In autumn slate-coloured juncos come from their summer homes in the dense north woods to our roadsides and scrubby fields. Near the juncos may be flocks of tree sparrows feeding on seeds among the bushes, and brown creepers creeping up the sides of nearby trees, searching for insects in every little crevice of the bark.

Our summer residents are the most numerous of our birds. On an early morning hike in late spring, we may see nearly 100 different species of these birds. Most of us recognize robins, song sparrows, red-winged blackbirds, meadowlarks, bluebirds, house wrens, bobolinks, Baltimore orioles, kingbirds, and scarlet tanagers—listed here in the usual order of their return from the south in spring—as well as several kinds of warblers. Because summer residents rear their young here, they destroy very large quantities of insects harmful to crops in summer.

Until bird-banding became a common practice, man had little definite knowledge about the travels of birds. Now, many people co-operate with the governments of Canada and the United States, working together, in banding birds. They catch birds in harmless traps, place a numbered band on one leg of each bird,

and set the birds free. Each bander sends to Washington a record of each bird banded. Later, when a banded bird is caught or is found dead, the date, the place, and the number on the band are reported to Washington. This information is added to the report sent in by the bander, and a complete summary is made for that bird. From all these summaries we learn much about bird migration — dates, routes, speed, and difficulties encountered along the route of migration.



FIG. 2-9. A ROBIN WEARING AN OFFICIAL BIRD BAND.

When do birds migrate? In August most birds are preparing for their southern trip or are already on their way. At this time of the year the swallows gather by hundreds on wires and in swamps to prepare for their flight to Brazil. By the end of September most of our summer residents have left us. Early in October the seed-eaters and shore birds that stayed behind are on their way. As the waters freeze, the ducks and geese fly past us to the south, while our winter residents are returning to us from the north.

Birds begin to come back from the south as early as February. The horned larks, accustomed to feeding on weed seeds, come then. In early March the cheerful notes of robins and song sparrows announce their return. In April the wrens and several kinds of sparrows and swallows wing their way to us. Nearly every day in early May brings more new species.

Why do some birds travel by night and some by day? Usually the smaller or more timid birds, such as the warblers, wrens, flycatchers, and most sparrows, migrate at night. Night travel enables them to avoid their enemies while flying and also gives them good opportunities for feeding by day.

Day travellers include ducks, geese, and cranes, which follow waterways; swallows, nighthawks, and swifts, which feed on insects in the air as they fly; also other fairly large birds, such as robins, bluebirds, and orioles.

How fast do birds travel during migration? Most birds take their time during migration, sometimes resting for several days, and seldom averaging more than 20 to 25 miles a day over the whole journey. Each kind of bird has its own particular speed of flight. Swifts may fly at more than 100 miles an hour, ducks and geese at 40 or 50 miles an hour, and flycatchers at less than 20 miles an hour.



FIG. 2-10. MIGRATION STORIES OF THREE COMMON SUMMER RESIDENTS.

What skyways do birds follow? Each kind of bird follows the migration route of its ancestors, whether it be long or short. Most birds that spend the winter in Central or South America come back to North America by one of the following skyways: (1) from South America across the Caribbean Sea to the islands of the West Indies, then to Florida and northwards; (2) by land through Mexico; (3) through Central America to the Gulf of Mexico, and across it to the Southern States, a distance of from 500 to 700 miles. The main routes northwards to Canada are along the Atlantic Coast and up the Mississippi Valley.

How do birds find their way? Birds generally begin and complete their journey on scheduled time. How they know their way, we cannot understand. The secret is theirs.

What dangers do migrating birds face? Thousands of night migrants, perhaps blinded by fogs, crash into tall buildings or lighthouses. Many small birds are forced down by head winds and storms while they are crossing bodies of water.

Why do birds migrate? The best answer seems to be that migration by birds is a habit inherited from their ancestors. We do not know how this habit started. We do know that birds that feed chiefly upon insects in the ground and in the air, and those that eat fruit and other foods that are not available in Canada in winter, migrate to the south. We cannot explain why they leave before there is a scarcity of food, or why many of them go much farther south than is necessary to obtain the food they like. Neither can we explain why they leave the comfortable climates of the south and come northwards in spring. Perhaps it is to escape overcrowding and to find better feeding and nesting sites; perhaps to escape some of their enemies.

Testing Exercises

1. State briefly how any 10 of the following are adapted: the cat, for eating meat; the cow, for obtaining and digesting grass; the giraffe, for eating leaves; the beaver, for swimming in cold water; the horse, for running; the squirrel, for climbing; the skunk, for avoiding enemies; the fawn, for avoiding detection; the cat, for self-protection when cornered; the dog, for running; the porcupine, for protection from its enemies; the whale, for keeping its body warm; the cat, for stalking prey.

2. List the activities carried out by beavers while building a dam.

3. How does a beaver's house provide for health, comfort, and safety?

4. Name three rodents and tell how their incisor teeth are adapted for gnawing. Why does gnawing not make their incisor teeth shorter?

5. Tell how the molar teeth of cats are adapted for cutting meat; and those of cattle, for chewing cud.

6. Classify the following mammals as carnivorous, insect-eating, hoofed, or gnawing: rabbit, mink, mole, squirrel, raccoon, beaver, Canada lynx, camel, seal, fox, horse.

7. Compare the adaptations of an aeroplane and of a bird for flight. See fig. 2-11.

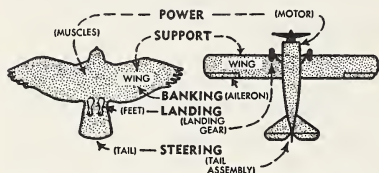


FIG. 2-11. COMPARE THE BIRD'S WING WITH THE AEROPLANE.

8. Describe how a woodpecker is adapted to cling to the side of a tree, to drill into the wood, and to extract an insect.

9. Name one bird as an example for each of the following types of birds and state one special feature of each type: birds of prey,

seed-eating birds, scratching birds, wading birds, swimming birds, and flycatchers.

10. Why does the upward stroke of its wings not force a bird downwards just as the downward stroke forces it upwards?

11. How do the body feathers of a bird help it to live in the air?

12. Classify the following birds as permanent residents, winter residents, or summer residents: downy woodpecker, robin, snowflake bird, chickadee, English sparrow, song sparrow, and meadowlark.

13. If a robin were to remain in Canada over winter, which would probably handicap it the more, low temperatures or a scarcity of suitable food?

Your Word List

Environment, adaptations, canine, incisors, molars, nocturnal, flesh-eating, carnivorous, insect-eating, hoofed, gnawing, rodents, streamlined, vane, prey, migration, migratory.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Beaver", Vol. B, pp. 88-92; "The 'Tiger' on the Hearth" (cat), Vol. C, pp. 135-136; "Man's Oldest and Most Faithful Friend", "How To Choose and Train Your Dog", Vol. DE, pp. 110-121; "Rabbits and Hares", Vol. QR, pp. 15-19; "Telling a Bird's Fortune by Its Feet", Vol B, p. 175; "Across Land and Sea with Animal Travellers", Vol. M, pp. 241-244; "Owl", Vol. NO, pp. 430-431; "How Goldenwings Learned To Fly", Vol. WXYZ, pp. 188 (4-page insert).

16 mm. Sound Films

Ontario Visual Education Branch

- Bobolink and Blue Jay (colour) (SN-16)
- Mammals Are Interesting (characteristics) (colour) (SN-118)
- Birds Are Interesting (colour) (SN-100)
- Birds of the Marshes (colour) (SN-11)
- Wildfowl in Slow Motion (flight) (SN-81)
- Water Birds (SN-79)
- Nature's Engineer (beaver) (SN-101)
- Mammals of the Countryside (colour) (SN-87)

National Film Board of Canada

- Birds of Canada, No. 3 (killdeer, plover, nighthawk, and cedar waxwing) (colour)
- Birds of Canada, No. 4 (spotted sandpiper, sora rail, and golden eye) (colour)
- Birds of the Seashore (colour)
- Birds of the Prairie Marshes (colour)
- High over the Borders
- New Homes for Beaver

Ontario Department of Lands and Forests

- Spearheads in the Sky (Canada Geese)

Film Strips

National Film Board of Canada

- The Beaver (colour)
- Larger Land Mammals of Canada
- Common Birds of Canada
- Animals Prepare for Winter
- Gannets of Bonaventure Island

3

HOW SOME OTHER ANIMALS ARE ADAPTED TO THEIR ENVIRONMENTS

WE HAVE DISCOVERED, in chapters 1 and 2, how insects, mammals, and birds are adapted by their habits and structures to live successfully in their natural surroundings. We shall now try to discover how several other types of animals are adapted to their environments, some in the soil, some entirely on land, some always in water, and some on land and in water.

The Earthworm, an Animal Well Adapted To Live in Soil

PUPIL INVESTIGATIONS.

1. *Out of doors.* Find little piles of earthworm castings on the lawn. Feel the fineness of the soil in them. Look for bits of vegetation pulled part way into the burrows. With a garden trowel, find the direction and depth of a burrow.

2. *Indoors.* (a) Set up observation homes for earthworms. Fig. 3-1 explains how. Place a few earthworms in each container. Keep the containers darkened with paper. Remove the papers occasionally to see how the worms are working.

(b) Place an earthworm on moist soil on a plate and study its actions and its structure. Can it move forwards? Backwards? Notice the changes in the size and in the length of the body as the worm travels. Feel the underside of its body for tiny bristles. Can an earthworm travel on glass? How do the bristles help it to travel?

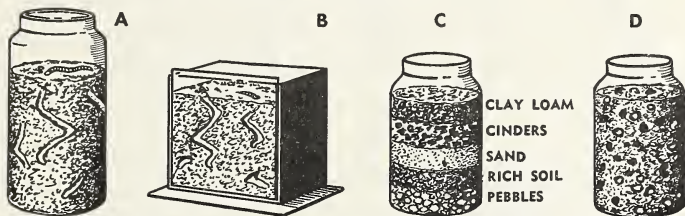


FIG. 3-1. OBSERVING EARTHWORMS IN THE CLASSROOM.

A, a glass jar with rich, moist soil and earthworms, kept dark; B, a wooden box with glass front, and cardboard cover over the glass; C, a glass jar filled with layers of pebbles, rich soil, sand, cinders, and clay loam, stocked with earthworms, and left darkened for several days; D, the results of the burrowing in C.

Home Life. The earthworm, or dew worm, lives wherever the soil is rich and moist. It abounds in decaying manure and plant refuse, and in fertile fields and lawns. Seldom do we find an earthworm in dry, sandy soil or under trees where roots use much of the food and moisture.

The earthworm is a peculiar animal. Without eyes, it can tell day from night; without ears, it can detect, by feeling, the light footfall of a bird; without feet, it digs its burrows; without teeth, it chews its food in its gizzard.

Burrowing. To dig burrows is easy for an earthworm. Its pointed front end is thrust easily into the soil, the upper lip helping both in digging and eating. The worm's powerful muscles enable it to push the soil aside and compress the sides of the burrow. Its long, slender, round body is well suited for making and living in burrows.

Travelling. An earthworm travels by lengthening and shortening its body. To lengthen the body, it anchors the back part with the bristles on its under surface and pushes the front part of the

body forwards. To shorten the body, it anchors the front part with the bristles and pulls the back part forwards. These two steps are something like putting one foot forward, then the other.

Feeding. An earth-worm both pushes and eats its way through the soil. Much of the soil from the burrow passes through the worm's body. The decayed plant materials in the soil are digested as food, and the indigestible parts are deposited on the surface of the soil as castings. For additional food, the earth-worm takes soft parts of plants, living or dead. Liquid from the mouth is poured on these to soften them. Then the worm sucks in and swallows the softened materials, which are then ground by tiny pebbles in the gizzard, making them more easily digested.

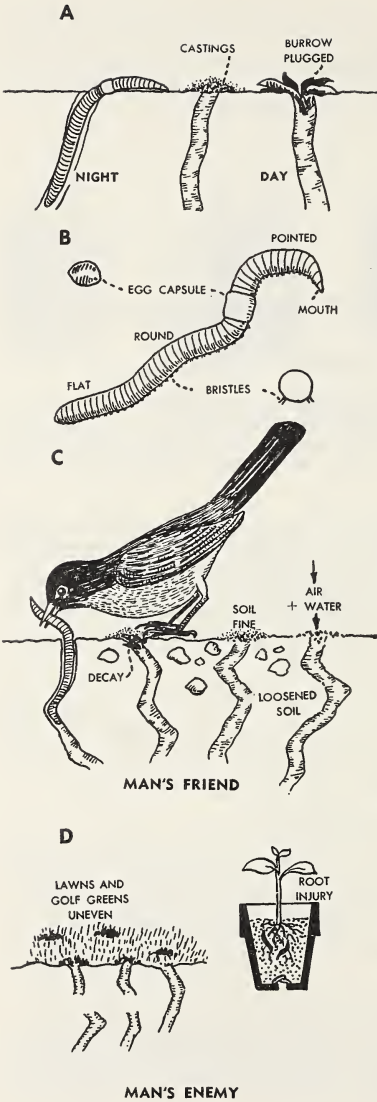


FIG. 3-2. THE STORY OF EARTHWORMS.

Breathing. An earthworm breathes through its moist skin. This explains why it lives in moist soil and avoids the dry air of day. Heavy rains may force the worm to come to the surface for air.

Earthworms Are Beneficial. The heaps of castings left by earthworms on lawns and golf greens leave the surface uneven, but raking will remedy this. Earthworms may injure the fine roots of potted plants. You can drive them out by resting the pot in a dish of strong limewater, made by stirring one cup of unslaked lime into six quarts of water and allowing it to settle.

The good done by earthworms far outweighs the harm they do. They plough and cultivate the soil by bringing their castings to the surface, thus constantly mixing the soil and making it finer. They enrich the soil in three ways: by covering plant remains with their castings, thus hastening decay; by pulling leaves and stems into their burrows; and by the digestive action in their bodies, which grinds vegetable matter and dissolves mineral substances, leaving them ready for plants to use as food. The burrows of earthworms allow air and water to enter and move freely through the soil. See fig. 3-2, C and D.

Earthworms are truly nature's ploughmen.

Answer These

1. Why do worms require moist soil?
2. How does an earthworm cling to its burrow when out feeding?
3. Why have earthworms been called nature's ploughmen?

Reptiles

The Garter Snake. As young children, we did not fear or shrink from garter snakes; perhaps we enjoyed playing with them. Any fear or prejudice we may now have towards these interesting creatures was probably given to us accidentally by some adult who, in his own mind, knew full well that they are perfectly harmless.

Garter snakes vary widely in colour. However, you will recognize them by the three yellowish, greenish, or light-coloured stripes on an olive-coloured or dark background.

The best way to understand the habits and adaptations of garter snakes, and to cultivate more friendly relations with them, is to make a comfortable home for one or two and keep them for a while in the classroom. All that is needed for a snake home is a closed box with a glass top or front to permit you to observe the snakes. A layer of sand should be placed on the floor of the box and, on it, a curled piece of birch bark or some sort of protective cover under which the snakes can retreat, also a dish of water and, occasionally, some food.

PUPIL INVESTIGATIONS. *Study some habits of garter snakes.*

Feed a snake earthworms or insects. How does it take them in and swallow them? How is its mouth adapted to take in large prey?

In what position does a snake usually rest? Can it travel straight ahead as easily as by a wavy motion? What bodily movements can you see as a snake advances? Examine the plates on the underside of its body.

Try to discover why a snake sticks its tongue out. Test the snake's power of seeing and of hearing.

Through the Year with a Garter Snake Family. Garter snakes are usually found in grassy or bushy areas, or near stony hill-sides or rocky ledges where they can find safe hiding places and suitable winter quarters. In autumn, they seek protective cover from which they can come out and sun themselves. They feed well and store fat to be used as fuel, for, although they become dormant in winter, they continue to breathe slowly. Before it is too cold, snakes burrow into the soil or enter crevices deep enough to be below frost.

In early spring, snakes again bask in the sun about midday. Soon they move from their winter sites to roadsides, fields, pastures, and parks and spend the summer devouring insects.

In late summer 12 to 50 young are born. These immediately find their own earthworms or other food. See fig. 3-3.

Habits and Adaptations of the Garter Snake. The garter snake eats insects, earthworms, frogs, and toads. Its jaws are adapted for taking in prey larger than the snake's own head, even large

frogs. The mouth can be opened very wide. When the snake has gripped an animal with its many sharp, backward-pointing teeth, it moves the two halves of its lower jaw alternately backwards and forwards to work the prey back to its throat. Then the muscles of the body force the victim into the stomach. While the food is being digested, the snake rests contentedly.

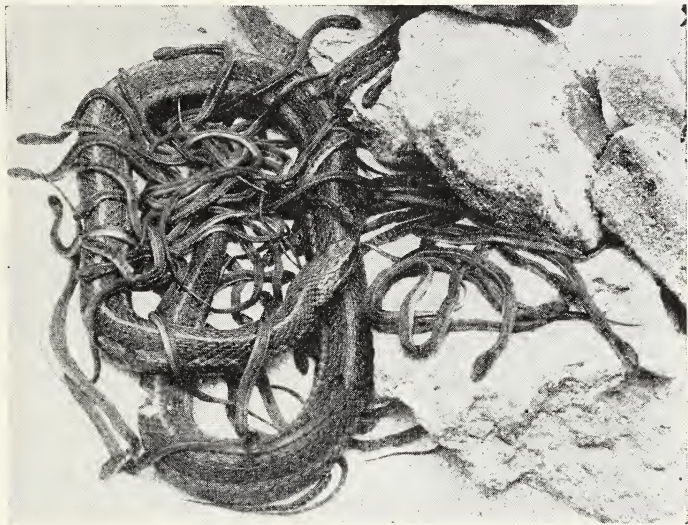


FIG. 3-3. A GARTER SNAKE FAMILY.

All these were born alive in one litter. How many heads can you count?

A snake usually glides smoothly along or “walks on its ribs”. Each plate on the under surface of the body is attached to the ends of a pair of ribs and helps the snake to move along. For greater speed, the snake also wriggles its body from side to side and pushes the sides of the curves against the ground. This same motion, assisted by the sideways movements of the tail, propels the snake in water.

To grow, a snake must shed its tough, scaly skin. This it does two or three times a year. When the transparent covering has been worked off the whole body—even off the eyes—the snake

is more beautifully coloured and is capable of increasing in size while the new skin is still soft. Young snakes moult more often than do older ones.

The chief enemies of garter snakes are hawks, crows, weasels, and man. Their protective colouration and their position on the ground helps them to avoid detection. Their habit of sticking out their tongues as a feeling organ tends to scare away enemies; and their retreat into holes and under cover helps them to avoid being caught.

Turtles. Turtles spend most of the time in water. They prefer mud-bottomed ponds surrounded by water weeds and shade trees, and containing partly-sunken logs and stones. They spend the winter in the mud at the bottom of a pond.

PUPIL INVESTIGATIONS. *Some habits of turtles.*

Visit a pond and search for turtles. Go quietly, and watch them as they walk, eat, and swim. Bring one or two back to the classroom so that you can observe them more closely. Notice how turtles walk, both in water and on the floor. Feed them bits of beef or small worms under water (for they always eat under water), and observe how they take these in. How does the shell protect the soft parts of the body?

Turtles eat either dead or live animals. They like frogs, tadpoles, snails, insects, and small fish particularly well. As turtles have no teeth, they bite the food with their sharp, horny-edged jaws. The painted turtle is a good scavenger, for it eats the remains of many water plants and animals.

Turtles can walk, climb, and swim. Their claws help them to climb on logs and stones, and their webbed hind feet enable them to swim.

The turtle's body is protected by hard, bony upper and lower shells. From this cover it stretches out its head, legs, and tail when it wants to eat or move, but it pulls them in rapidly when danger threatens. The head, neck, legs, and tail are also protected by a covering of scales. This covering of scales is characteristic of all reptiles.

The shape, surface, and colour markings of their shells distinguish different kinds of turtles. The common *painted turtle*

has a dark, scarlet-bordered upper shell; the *snapping turtle's* upper shell is higher and rougher, and is a dull brown in colour.

Turtles breathe by means of lungs, and must therefore come to the surface to get air.

Turtles go to nearby land to lay their eggs. These they hide either in soil or in decaying plant remains where the warmth of the sun causes them to hatch. The soft, leathery shells of the eggs are easily broken by the young turtles when they are ready to emerge. At that time they resemble their parents in all respects except size.

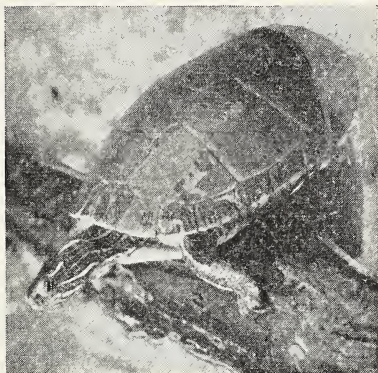


FIG. 3-4. THE COMMON PAINTED TURTLE.

Reptiles Are Useful to Man. Snakes, in general, are beneficial because they eat beetles, crickets, caterpillars and other insect larvae, grasshoppers, slugs, rats, and mice, all of which are injurious to man, his crops, or other plants. They do eat a few useful animals such as frogs, toads, and birds. The eggs of some turtles are cooked for food, and the bodies of others are used to make soup. Fine leather is made from the hides of crocodiles and alligators.

Characteristics of Reptiles. See the table, chapter 4, page 77.

Review Questions

1. How are snakes and turtles similar? How are they different?
2. What food taken by snakes makes them useful to man? What beneficial animals do snakes eat?

Animals That Live in Water

Fish. Every living thing must breathe and eat, and, in order to find food, most animals must travel. Living in water presents

problems very different from those of living in air. Let us find out how fish solve the problems created by living in water.

Although fish always live under water, they vary widely in habits. Some, like the brook trout, live in fast streams and feed on flies caught at the surface; others, like the eel and the mudcat, live and search for worms on the muddy bottom. Some fish spend a lifetime in one stream; others, like the eel and the salmon, travel long distances in both fresh and salt water. But all fish have somewhat similar habits, and very similar adaptations for travelling, feeding, and breathing.

Travelling and Floating.

PUPIL INVESTIGATIONS. *How is a fish adapted for swimming?*

Watch fish swimming either in a stream or in your school aquarium. In what directions can they swim? What seems to be their main propelling organ? What fins do they use to turn round? To raise and lower themselves? To balance the body erect? What fins seem to take the place of arms? Of feet? Which fin corresponds to a rudder? Which corresponds to a keel? Can fish remain motionless in water? Do they seem to exert any effort in raising or lowering themselves?

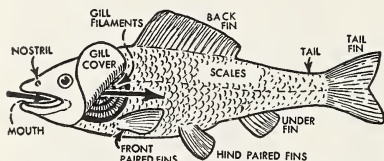


FIG. 3-5. FISH ARE WELL FITTED
TO LIVE IN WATER.

Draw a fish, then label your drawing like this one.

The tapering rear end of a fish and all of its fins adapt it well for swimming. The tail and the tail fin are the chief organs of locomotion. Their position, flexibility, and size enable them to propel the fish forwards and to serve as a rudder.

The under fin and the back fin serve as keels and help to keep the fish erect. The front and hind paired fins are used for balancing and for raising and lowering in the water.

PUPIL INVESTIGATIONS. *How does the structure of the fins fit them for their work?*

Examine and feel the fins of a dead fish. What gives them strength? What makes them flexible? With what is the bony framework covered? What would be the disadvantages of stiff fins?

The bony framework of fins makes them strong, and the membranous cover gives them a good pressing surface.

PUPIL INVESTIGATIONS. *How does the shape of a fish help it to travel through water?*

In what ways are fish and birds similarly adapted for travel? Of what advantage is the "streamlined" shape of a fish?

The tapered shape of a fish's body gives it flexibility and reduces the resistance of the water to its forward motion. This helps the fish to propel itself forwards easily.

PUPIL INVESTIGATIONS. *How does its covering adapt a fish for locomotion in water?*

Feel the body of a dead fish. What makes it slippery? Notice how the scales are arranged. How do they protect the fish from injury without hindering it while swimming?

Because the scales of a fish overlap each other and point backwards, they protect it well from injury without handicapping it in any manner when swimming. The slippery coating of mucus or slimy material always present on the body of a fish reduces friction by the water when the fish is swimming. It also protects it against fungus diseases.

Fish float in water with little or no effort. The swim bladder in a fish, filled with air, makes the body so light that the buoyancy of the water can hold it up. By enlarging the size of this gas bag, the fish can make its body light enough to rise in the water; by reducing the size, it makes its body heavy enough to settle lower.

Feeding.

PUPIL INVESTIGATIONS. *How do fish obtain food?*

Feed your fish small worms, flies, or commercial fish food. Do the fish prefer living or dead food? What shape is the fish's mouth when open wide? In what directions does a fish move its lips as it opens its mouth and takes in food? Feel in the mouth of a fish to discover how its teeth are fitted to prevent living prey from escaping.

Small fish feed on microscopic plants and animals in water, and large fish feed on smaller fish or on flies, water insects and

their larvae, and worms. When fish have detected their food, they must go after it and seize it in the mouth, for they have no feet or other structures with which to grasp it. They open the mouth very wide and take in their prey alive and whole. Numerous fine, sharp teeth on the jaws and the roof of the mouth keep struggling prey from escaping before it is swallowed.

Breathing. Land animals breathe by taking oxygen from the air. Fish must take their oxygen from the small amount of air that is dissolved in water. For this they have special organs called gills on both sides of the head, just behind the jaws.

PUPIL INVESTIGATIONS.

1. *How do fish get fresh water to their gills?* Find the gills of a dead fish under flaps of skin on the sides of the head behind the eyes. Notice the opening and closing of a live fish's mouth and of its gill covers (fig. 3-5). Which opens first? Place a drop of ink in front of the fish's mouth. Watch the coloured water come out from under the gill covers. How often does the mouth open each minute?

2. *How are the gills fitted for breathing?* Tip forwards the gill covers of a dead fish. Find the delicate, red fringes beneath them. These are a part of the gills. What makes them red? How many gills are there on each side? How does the water get out from the mouth cavity?

The water passing through the mouth and between the gills carries with it a little dissolved oxygen. This oxygen passes from the water into the blood in the gills and is circulated throughout all parts of the body. The waste carbon dioxide is brought back to the gills by the blood and then is given off to the outgoing water.

The delicate gill parts that you see, the gill filaments, are divided into a large number of tiny sections through which the blood circulates. For this reason, there is a very large gill surface in contact with the water flowing past. The larger this area, the more oxygen can pass from the water to the blood, and the better chance the waste carbon dioxide has of getting away.

The Life History of Fish. Most kinds of fish reproduce by means of eggs, although a few give birth to living young. Many

species of fish lay several thousand eggs, but a large percentage of these are devoured by enemies before they can hatch. The eggs may or may not be cared for by the parent fish.

Fish as Food. This topic will be studied in chapter 21.

Characteristics of Fish. See chapter 4, page 77.

Things To Do

1. Set up and maintain a balanced aquarium.
2. Name some birds and other animals that feed on fish.
3. Visit a local stream or lake and make a list of ways in which the water is both favourable and unfavourable for fish.

Think These Through

What is the advantage of a fish facing upstream? What changes take place in the water as it passes between the gills? Why is it necessary either to have plants in an aquarium or to change the water frequently? Why do fish in an aquarium sometimes come to the surface of the water?

Clams. Imagine an animal that gets its food without working for it, has its intestine in its foot, walks without a leg, and uses a fish as a taxi. A clam is such an animal.

A clam rests in the sand at the bottom of a lake with its foot extended out of its partially opened shell into the sand. Here the foot serves as an anchor until the clam decides to move on (fig. 3-6).

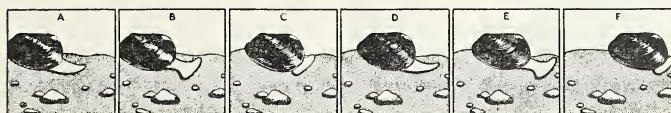


FIG. 3-6. THIS CLAM HAS WALKED TWO STEPS.

A. The clam extends its foot into the sand. B. The tip of the foot is enlarged and acts as an anchor. C. The muscles of the foot shorten, drawing the body and shell of the clam forwards. D. The foot is extended again. E. The tip is anchored. F. The body is drawn forwards again.

A clam eats as it breathes. Two fringed tubes extend out barely past the edges of the clam's shell. The lower tube takes in water containing dissolved oxygen for breathing and tiny water plants for food. The upper tube carries away body wastes and the carbon dioxide produced by breathing.

Young clams are hatched within the shell and escape through the tube that carries away waste water. If the right kind of fish comes along at the right time, the young clam steals a ride by grasping the gills or fins of the fish. As the young clam travels, it feeds and grows. Finally, it falls, sticks its foot into the sand, opens its shell and water tubes, and lives the life of an adult clam.

Snails.

PUPIL INVESTIGATIONS. *Some habits and adaptations of snails.*

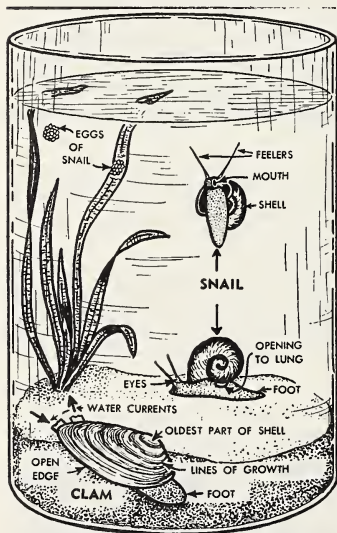


FIG. 3-7. A SIMPLE AQUARIUM FOR YOUR CLASSROOM OR HOME.

How do the clam and snail differ in their feeding habits? In locomotion? In breathing? In life history?

Place some sand, water, water plants, and water snails in a quart sealer in the classroom. Look for the following: (1) a snail's feelers frequently bending about, and the eyes near the base of them; (2) the back-and-forth motion of a snail's tongue just under its chin and at the front of its foot, scraping off green scum from the glass or the plants for food; (3) the way a snail glides along on the glass, or even upside down beneath the surface of the water; (4) a snail coming to the surface occasionally to get more air; (5) the way a snail draws into its shell when disturbed; (6) the jelly-like masses of eggs on little sticks or leaves, or even on the glass.

Snails are queer creatures, too. They always move by

sliding along on their smooth, flat feet. Whenever they wish, they crawl back into their shells and close the door, taking in with them enough oxygen to last for several hours. As you have observed, they feed upon plant material.

Amphibians: Animals That Live Both on Land and in Water

Frogs. Frogs at Home. Frogs are most at home when in or near lakes, ponds, marshes, and even small streams. Here they come each spring to lay their eggs, and here they find food, a ready means of escape from their enemies, and the moist atmosphere which they require. In summer many frogs wander away from the water into low meadows, pastures, or roadsides.

PUPIL INVESTIGATIONS. *Visit a marsh or a pond where frogs are plentiful.*

In what position do frogs usually rest in the water? Why must the eyes and nostrils be above the surface of the water (fig. 8-3,A)? How does this position protect them? In what other ways do they avoid being seen by their enemies? What birds and other enemies of frogs are commonly seen around frog ponds? Disturb a floating frog and observe by what methods of locomotion it escapes. Catch a frog. How is it adapted to escape from your hands?

A frog among the reeds in a pond is not only well protected from its enemies, but it is conveniently situated for breathing, eating, and travelling. The surrounding logs and plants provide hiding places that give it safety from fish, snakes, birds, and man. Its brown and green colours so harmonize with dead and living plants, and its spots so resemble shadows, that even its most observant enemies are not likely to detect it. Its ability to float with its eyes above water permits it to detect its enemies and to dive from them at a moment's notice, as well as to see an insect passing near enough to be caught. All the while, it can breathe freely through its nostrils above the water level.

The Frogs' Food and Feeding Habits. An acceptable menu for frogs includes some of these: earthworms, spiders, flies, bees, wasps, beetles, other insects, snails, and even smaller frogs and tadpoles.

PUPIL INVESTIGATIONS. *How do frogs obtain their food?*

Keep some frogs in a vivarium or in a vessel containing a shallow layer of water. Feed them earthworms. Carefully observe how a frog reaches for and takes in food. What use does it make of its feet while it is feeding? Feel the teeth on the roof of a frog's mouth and on its upper jaw. What purpose do they serve?



FIG. 3-8. A SKILFUL TONGUE.

A frog takes nearly all its food whole. Its front feet often serve as hands by helping to push the end of an earthworm or other large prey into its widely opened mouth. Fig. 3-8 shows how a frog catches a fly. The sticky tongue, attached at the front end, is flipped forwards and over the fly, then it is unrolled back into the mouth where it places the food in the throat—all so quickly that one hardly sees the insect disappear. Because a frog's throat is so large and so easily stretched, larger animals, such as earthworms, can be swallowed without being chewed. A frog's fine, sharp teeth help to keep prey from escaping.

How Frogs Travel.

PUPIL INVESTIGATIONS. *Observe a frog in an aquarium or in a tub of water.*

What position does it take (a) when floating, (b) when ready to swim? How does it push itself forwards in water?

Place a frog on the floor. What is its position when ready to jump?

How far can it jump? What adaptation is common to frogs and other animals that jump long distances?

Frogs may travel by diving, swimming, leaping, or crawling. Diving provides immediate safety from enemies. A frog can swim rapidly because of the muscular nature and the great length of its hind legs, and because of the webbing between the toes of its hind feet. Because its hind legs are so long and strong

and are attached so near the middle of its back, a frog can take long, accurately directed leaps. To crawl about on logs or rocks, a frog uses its short front legs and feet.

How Frogs Breathe.

PUPIL INVESTIGATIONS.

Observe the breathing movements of a frog's throat, nostrils, and sides. Count the number of each in a minute. Place a frog under water, and find out how long it remains there without coming to the surface for air.

To inhale, a frog opens its nostrils and lowers the floor of its mouth. This allows outside air to move in. Then the frog closes its mouth and nostrils and raises the floor of its mouth to force the air down to its lungs. Later, it opens its nostrils and draws in its sides to force the impure air out from its lungs.

Frogs also breathe through the skin to a certain extent. For this reason, the skin must always be moist. To keep it so, frogs remain in moist places most of the time. When we handle frogs, we should first moisten our hands.

Through a Year with the Frogs. When ready to hibernate in autumn, frogs must have enough fat to provide fuel for breathing all winter and to produce eggs in the spring. While frogs are under streams in winter, the lungs are empty, but oxygen is taken into the body from the mud by means of the moist skin. In early summer, frogs feed greedily and soon regain the weight lost in winter and spring.

The Life Cycle of a Frog. The study of this topic and the investigations connected with it should be postponed until spring.

PUPIL INVESTIGATIONS. *Observing the development of frog's eggs and tadpoles indoors.*

Collect eggs of frogs in a marsh or pond. You will find them in jelly-like masses floating in the water and usually attached to plants. Each egg consists of a tiny dark central part resting on a whitish background.

Put a few of the eggs in an aquarium containing pond water and some water plants to supply oxygen. Place the aquarium in good light, but not in direct sunlight.

As you find answers to the questions that follow, write a diary of the changes in the eggs and in the developing tadpoles. Can you see the shape and movement of the little tadpoles before they leave the eggs?

How do the tadpoles attach themselves to plants when they are not swimming about? What do they eat? How do they swim? Which legs develop first? How do they move about then? Why do tadpoles start coming to the surface for air? Why do they not need a tail after they have four legs? Compare your observations with what you see in fig. 3-9.

The tiny tadpoles at first attach themselves to plants, but do not eat. Soon they develop mouths and feed on plant materials. Like fish, tadpoles breathe by means of gills and use their tails



FIG. 3-9. THE LIFE STORY OF A FROG. How do the habits of feeding, travelling, and breathing change as the tadpole develops into a frog?

for swimming. After they have developed their legs, tadpoles use them for swimming, as frogs do. At about the same time, the mouths of the tadpoles change to a form better fitted to catch insects than to eat plants. From then on, they come to the surface for air and breathe by means of their newly developed lungs.

Toads. The common toad is adapted for its way of living much as a frog is. The following table outlines the main differences between frogs and toads.

How Frogs and Toads Differ

	Frogs	Toads
Habitat	Near water	Away from water, except when they lay their eggs
Body	Not as stout as toads	Stouter than frogs
Skin	Smooth	Rough, warty
Hind Legs	Strong, for jumping	Weaker, for hopping
Hind Toes	Webbed	Less completely webbed
Eggs	In masses	In strings
Tadpoles	Lighter in colour	Darker; mature sooner
Tongue	Same	Same
Hibernation	In mud	Deep in soil



FIG. 3-10. THREE COMMON AMPHIBIANS.

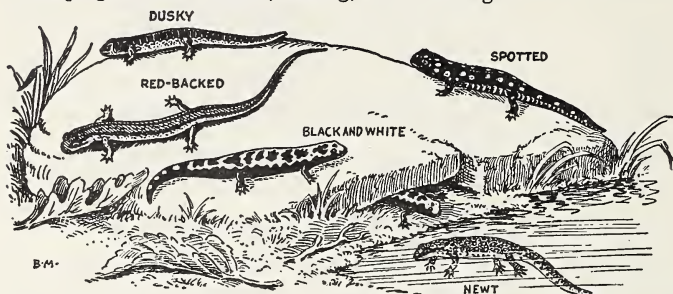
A, the pickerel frog, recognized by its four rows of "suarish" dark spots; B, the leopard frog, having two irregular rows of rounded or oblong dark spots and a few extra spots; C, the common toad, stouter than a frog and having a rough, warty skin.

Frogs and Toads Are Valuable to Man. Frogs and toads are entirely beneficial to man. Both have such voracious appetites that they eat large numbers of harmful insects, many from our gardens. The value of one toad, through eating cutworms alone, has been estimated at close to \$20.00 in one summer season. In the same period, it devours also thousands of other insects and slugs. The legs of some kinds of frogs are a highly prized food.

Things To Do

1. Write the biography of a frog, covering a period of one year.
2. Find and name two or more kinds of frogs.

3. Train a frog or a toad to eat worms from your hand.
4. Look under decaying logs and under stones in damp places for newts and salamanders. These amphibians are illustrated in fig. 3-11.
5. Describe the adaptations of a frog for: swimming, avoiding or escaping from its enemies, feeding, and breathing.



(From Athey's "Along Nature Trails", copyright. Used by permission of American Book Company, publishers)

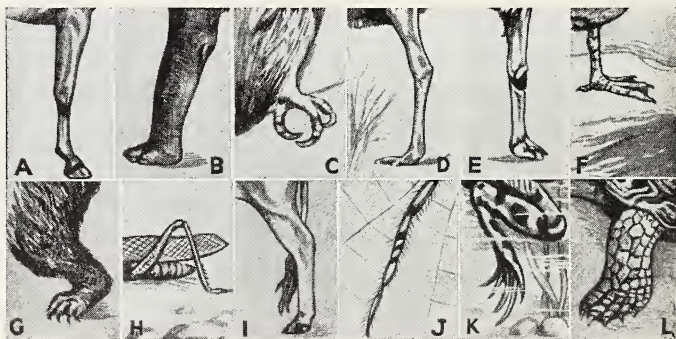
FIG. 3-11. SALAMANDERS.

Your Word List

Reptiles, amphibian, indigestible, beneficial, protective colouration, buoyancy, microscopic, aquarium, life cycle, tadpole, hibernate, voracious.

A Picture Test for Unit 1

Figure 3-12 shows the feet of several animals you have studied, and of a few you have not. Name all you can of these and discuss in class how each is adapted for its work.



(Compton's Pictured Encyclopedia)

FIG. 3-12. ANIMAL FEET ADAPTED FOR MANY WAYS OF LIVING.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Nature's Most Expert Spinners and Weavers", Vol. S, pp. 342-348; "Snakes—Creatures That Walk on Their Ribs", Vol. S, pp. 205-209; "The Life Story of the Common Toad", Vol. TUV, pp. 140-141; "Aquarium", Vol. A, pp. 279-282; "Fish", Vol. F, pp. 99-107; "The Amazing Actions of a Common Frog", "All About Frogs and Polliwogs", "The Tadpole Who Wanted To Be a Frog", Vol. F, pp. 298-301.

16 mm. Sound Films

Ontario Visual Education Branch

Snapping Turtle (SN-73)

Snakes Can Be Interesting (SN-122)

The Frog (SN-31)

National Film Board of Canada

Salmon Run (colour)

Red Runs the Fraser (colour)

Ontario Department of Lands and Forests

Shadow in the Stream

Demons of the Deep

Ryerson Film Service, Toronto

Life in an Aquarium

Answers to Picture Test (fig. 3-12)

A, horse; B, elephant; C, eagle; D, ostrich; E, camel; F, duck; G, bear; H, grasshopper; I, ox; J, spider; K, frog; L, tortoise.



UNIT TWO

Plants, Animals, and Man

4. *THE PLANT AND ANIMAL KINGDOMS*

All things that make up the earth and its inhabitants may be classified as living or non-living. Living things belong to either the plant kingdom or the animal kingdom. Only green plants can live on soil, water, and air alone. All other plants and animals depend upon green plants for food.

5. *INSECT FRIENDS AND FOES*

Some insects are helpful to man; others are harmful. Beneficial insects make honey, provide silk, and control insect pests. Harmful insects attack or destroy man's plants and animals, damage clothing and household goods, or cause discomfort and ill health.

6. *BIRDS IN RELATION TO MAN*

Our feathered friends give us pleasure, control injurious insects and mammals, devour weed seeds, and provide us with food and sport. In return, we should provide them with food, shelter, nesting sites, and protection from their enemies.

7. *THE WEB OF LIFE*

Just as the threads in a piece of cloth are woven together, so the plants and animals that inhabit the earth depend one upon another. Among all living things in any locality, Nature has established a sort of balance, all too often interfered with by man.

4

THE PLANT AND ANIMAL KINGDOMS

Living and Non-Living Things

EVERYTHING THAT WE CAN THINK OF is either a plant, an animal, or a non-living thing. The following exercise will test your understanding of this statement.

A Testing Exercise

In your notebook, rule three columns headed *Plants*, *Animals*, and *Non-living Things*; then write, in the order given below, each of the following names in its correct column: ant, newt, pansy, nail, insect, lily, oxygen, mouse, note, land, apple, ink, narcissus, vase, inch, tea, sugarcane, armadillo, noon, leopard, grate, skunk.

If your lists are correct, the first letters of the words in each column will spell out the heading of the column.

Look at your list of plants. Each of these plants breathes, uses food, and grows; each can produce new plants. The leaves of each plant bend towards light, and the roots of each grow towards moisture: we may say plants move to some extent.

The animals named in your second column also breathe, use food, grow, reproduce, and move.

Can the non-living things listed in column three do any of the things the living plants and animals do? No, none of them breathe, use food, grow, or reproduce. Ink may flow downwards, and oxygen, as a part of the air, may circulate, but none of these non-living things can move without outside help.

A cat's paw can produce new skin to replace the old, worn skin, but the leather soles on our shoes cannot grow new leather to replace leather worn away; neither can an automobile replace worn parts. A geranium in a flower pot can grow, but the pot itself cannot grow. The automobile, the flower pot, the leather soles, and all the things listed in your third column as non-living things cannot breathe, use food, repair themselves or grow, reproduce, or move about of their own accord.

The bodies of all living things, both plants and animals, are made up of tiny units called cells. Most of such cells can be seen only through a microscope. They fit together in various ways to form all parts of the body of the plant or animal, somewhat as bricks or stones are fitted together to make a wall, a fence, or a building. Some very tiny and simple plants and animals are made up of only one cell or a few cells. Most plants and animals we see around us consist of thousands or millions of cells. Nearly all of the cells of a living plant or animal are alive, and all of its cells were once alive. Living cells are always made up of *protoplasm*, a special kind of colourless substance, somewhat like the white of an egg, enclosed by a cell wall. Protoplasm is a very important substance because it distinguishes living things from non-living things.

The Plant Kingdom

How Green Plants Live. We learned, in *General Science*, Book 1, that green plants make their own food from water, minerals, and carbon dioxide. Roots absorb water from the soil, and the water carries in dissolved minerals with it. Leaves take in carbon dioxide from the air. To make these raw foods into usable plant foods, green plants must have light. When the sun shines on green leaves, the green colouring matter, chlorophyll,

serves as machinery and uses the sunlight as power to combine the water, minerals, and carbon dioxide and produce sugar or starch. These plant foods nourish the green plants and enable them to grow.

As a green plant manufactures food, it gives off oxygen and surplus water as waste substances. These escape from the leaves.

Green plants, like all other living things, must always breathe. Their leaves, stems, and roots all do this by taking in oxygen and giving out carbon dioxide.

In addition to oxygen for breathing, the raw materials mentioned above for food, and light with which to make these into usable plant foods, all green plants must have some degree of warmth.

Plants That Depend upon Others for Their Food. No doubt you have seen mushrooms growing in a lawn, a pasture, or a wood, and bracket-like objects growing on trees or stumps. You will recall that these growing plants have no green colour. You know, therefore, that they cannot make their own food. Nature has placed on the earth many other kinds of plants that cannot make food for themselves. How, then, can they live?

Mould, Mushrooms, and Bracket Fungi. Mould on bread is similar in some ways to a mushroom plant. An experiment will teach us how it lives.

EXPERIMENT 4-1. *Grow some bread mould.*

Place a slice of moist bread on three or four thicknesses of wet blotting paper in a soup plate. Leave the bread exposed to air for half an hour, then cover it with glass. Place the plate in a warm place, not exposed to sunlight. Keep the bread moist.

Watch for a white, cottony growth of mould on the bread. Because it grows, we know the mould is living: it is a plant. Notice that the bread is reduced in size as the mould takes food from it for growth.

Has the mould plant any green colour? Why, then, can it not make its own food?

Watch for black specks to form on the mould plant. Each speck is a collection of tiny, dark spores. Like seeds, these spores are able to produce new mould plants when given food, moisture, air, and water.

Mould, similar to the one you have grown, often grows on fruit. All such mould plants lack chlorophyll and, therefore, cannot make their own food. They get their food from the substance on which they grow, and this food must have been made previously by the green plants that made possible the bread or the fruit.

A mould plant has no roots or leaves. It consists entirely of a tangled web of branching, fine, white, thread-like strands on and within the bread or fruit. Each little strand can absorb food.

When old enough, some of the little strands produce knobs filled with spores. These spores are carried by air to bread or fruit elsewhere and produce new mould plants.

Mushrooms live and grow somewhat like mould plants. Because they have no chlorophyll, they cannot make their own food and, therefore, do not need light. They must get food previously made by green plants. Therefore, we find mushrooms only where the soil contains much decayed plant matter.

A mushroom plant consists of a delicate, web-like growth in the rich soil, somewhat like the mould plant. This growth and some of the soil held together by it is called spawn. From this underground part a small growth, something like a peanut, and called a button, appears above the ground. This grows

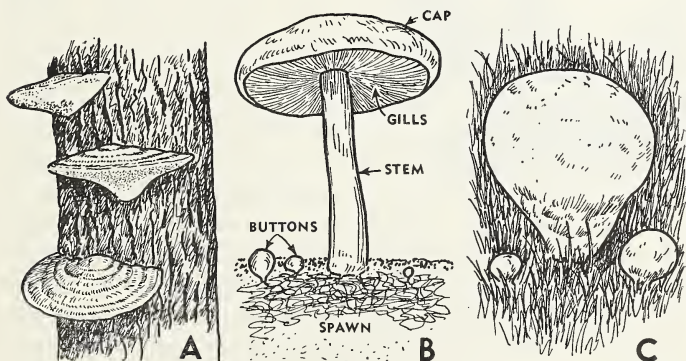


FIG. 4-1. THREE PLANTS THAT CANNOT MAKE THEIR OWN FOOD.

A, bracket fungi; B, a mushroom plant; C, puffballs.

taller and opens like an umbrella to form the top or cap of the mushroom. Spores are produced on the underside of this cap, spread elsewhere, and produce new mushroom plants. Now study fig. 4-1, B.

Some mushrooms are good to eat; others, often called toadstools, are poisonous. It is never safe to pick any mushroom for food unless someone who knows has told you that it is edible.

Plants, like mould and mushrooms, that cannot make their own food are called *fungi* (singular, *fungus*).

Two other kinds of fungi that take their food from dead plants or their remains are bracket fungi and puffballs. Bracket fungi grow like little shelves against the sides of stumps, logs, or trunks of trees. Puffballs are round in form and grow in rich soil or on decaying logs. When young, they are white and solid; when mature, they are like thin, brown shells filled with millions of tiny, dark spores.

Plant Diseases. Some fungi obtain their food from other living plants while living on or within them. These fungi are usually visible on the outside of some part of the plants in which they live. Most of us have seen one of these: potatoes with hard, round or irregular, rough spots on them (*potato scab*); apples partly covered by dark-coloured, roundish "scabs" (*apple scab*); ears or tassels of corn bearing large, silvery-white "boils" containing a mass of black powder (*corn smut*); heads of oats with the kernels replaced by an irregular black mass of powder (*oat smut*); leaves of roses or lilac covered with a thread-like layer of mildew (*rose mildew* or *lilac mildew*); leaves and stems of wheat marked by long, narrow, rusty-coloured streaks (*wheat rust*); or irregular, dark, knot-like growths on plum or cherry twigs (*black knot*). Any one of these observations indicates that a fungus is growing or has grown within the plant. We call the fungus a plant disease because it weakens or destroys a part of the plant on which it feeds. The names of the plant diseases are given in the brackets after each description above.

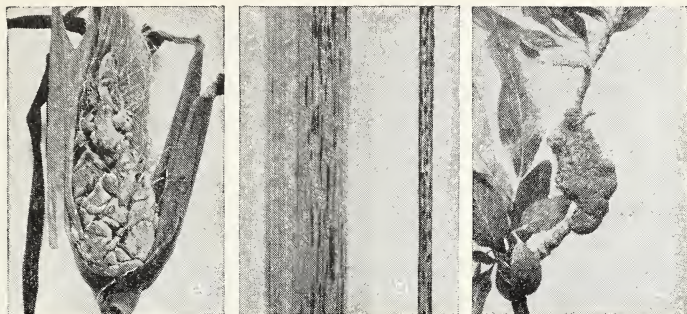


FIG. 4-2. PLANT DISEASES THAT STEAL FOOD FROM CULTIVATED PLANTS. A, corn smut, destroying an ear of corn; B, leaf and stem of wheat bearing wheat rust; C, black knot on a cherry tree.

Bacteria: Friends and Foes. Although we learned a great deal about bacteria in *General Science*, Book 1, some of them are so useful and others so dangerous that we should review them.

Bacteria are tiny, living plants, so small that they can be observed only through a microscope (fig. 4-3). Although we do not call bacteria fungi, they have no green colour and, therefore, cannot make their own food or use light. Bacteria depend upon other plants or upon animals to provide food for them.

Bacteria occur almost everywhere—in the air, in water, in soil, in most foods, and in the bodies of plants and animals, including man. Wherever they are, they require food, moisture, warmth, and, in most cases, oxygen to live and multiply.



FIG. 4-3. STUDYING BACTERIA WITH A MICROSCOPE.

The observer has discovered rod-shaped bacteria of tuberculosis, as shown in the circle. What does the figure of the thief represent?

EXPERIMENT 4-2. *Grow some bacteria (fig. 4-4).*

1. Sterilize a few vaseline bottles by leaving them in boiling water for half an hour. Make beef broth by boiling in $1\frac{1}{2}$ pints of water for 20 minutes one of the cubes sold for this purpose. To the solution, add enough gelatin to make it thick when cool. Place $\frac{1}{2}$ inch of this solution in each of several sterilized bottles and plug them loosely with sterile cotton.

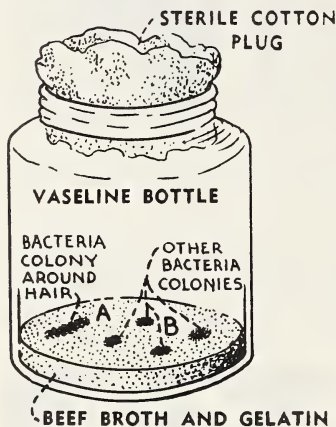


FIG. 4-4. MAKING A BACTERIA GARDEN.

Place one of the following on the beef-gelatin in each bottle: a little dust, a pinch of soil, a drop of rain water, a hair, a drop of saliva, and food picked from the teeth. Again plug the bottles carefully and leave them in a warm place.

Circular spots of various colours on the beef-gelatin will show that bacteria were added with the materials placed on the gelatin and are multiplying.

2. Plant more bacteria gardens and try to discover the effects of sunlight, of coldness, and of a drop of disinfectant upon the growth of bacteria.

Bacteria may be useful, harmful, or just harmless. Some kinds of useful bacteria enable us to make butter and cheese, cure tobacco, and tan leather; some serve us by causing the decay of plant and animal refuse; and others make the humus in soil useful for green plants.

Some kinds of harmful bacteria cause food to spoil, some cause lumber to decay, and others produce dangerous diseases in our own bodies or in those of our domestic animals.

Disease-producing bacteria are spread in impure water, food, and milk, and by lice, fleas, and house flies. We may also take them into the body through a break in the skin, with the air we breathe, and by putting infected articles into the mouth.

The safest precaution against diseases caused by bacteria is to prevent the germs from reaching or entering the body. Some

of the most effective means of doing this are: keeping all surroundings and utensils clean and sanitary, using only safe water and pasteurized milk, covering food and storing it where it remains cool, using germicides, fumigating infected places, and quarantining people who have a communicable disease.

When bacteria have once gained a foothold within us, the white corpuscles in our blood help in their control by devouring them. Doctors may help by injecting serum or vaccines into the body to counteract the harmful effects bacteria may have if they gain admittance.

The Animal Kingdom

How Animals Differ from Plants. Although all living things are either plants or animals, it is difficult to state clearly how plants and animals differ. We learned earlier in this chapter that all living things breathe, use food, grow, reproduce, and move. The term plants includes all the green plants such as trees, flowers, fruits, vegetables, grasses, and ferns, and all those special kinds of plants that cannot make their own food. The term animals includes all mammals, birds, reptiles, frogs, toads, fish, insects, and worms, in addition to the many types of tiny microscopic forms.

Let us try to discover how animals differ from plants. First, animals in general have greater freedom of movement than plants. A cat can frisk about by its own efforts and as a result of its own decision. Its whiskers and ears may twitch even while it sleeps. A cat can feel hungry and choose to eat, or it can feel heat and decide to move towards it. Most animals have similar powers of moving of their own accord. Their well developed senses detect changes in their environment, and they act as they see fit. On the other hand, the stems and leaves of most plants bend towards light, their roots grow towards moist soil, and the buds of their leaves and flowers open. Plants, however, cannot decide upon such movements: they are controlled by outside causes.

Second, animals differ from plants in their methods of obtaining nourishment. Green plants can make their own food from non-living things; animals cannot. Animals must get nourishment from plants, or from other animals that feed upon plants.

Third, the walls of plant cells are made up of *cellulose*. This is the material that gives firmness to the trunks and twigs of trees, the veins of leaves, and the fibres of cotton. The walls of animal cells do not contain cellulose.

Animals differ from plants in their methods of reproducing themselves. Animals usually lay eggs or give birth to living young. Most plants reproduce by seeds, by spores, or by parts, such as cuttings, taken from their own bodies.

Animals with Backbones. The main part of the skeleton of a horse, a bird, a snake, a turtle, or a fish is its backbone. This holds most of the other bones in their proper positions and gives the animal its characteristic shape. With the help of the brain and the nervous system, the backbone also controls the animal's methods of moving and travelling.

We have already learned that animals with backbones are divided into several classes, namely mammals, birds, reptiles, amphibians, and fish. Of these, the mammals and birds are known as *warm-blooded animals* because the temperature of their bodies remains quite constant, usually warmer than that of their surroundings. The normal temperature of man is 98.6°F.; that of birds ranges from 100°F. to 112°F. A well-developed system of breathing and circulation and a body covering of hair or feathers help warm-blooded animals to maintain a high body temperature.

The body temperature of reptiles, amphibians, and fish remains about the same as that of the air, soil, mud, or water surrounding them. For this reason, they are described as *cold-blooded animals*. Because cold-blooded animals do not need to have body heat retained in the body, they do not need an insulating covering of feathers, hair, or fur such as birds and mammals require.

Animals with Backbones

		WARM-BLOODED ANIMALS		COLD-BLOODED ANIMALS		
		Mammals	Birds	Reptiles	Amphibians	Fish
Skeleton		Bony	Bony	Bony	Bony	Bony
Body Covering		Hair or fur	Feathers	Snakes and turtles, a scaly skin; turtles only, a hard bony shell	Smooth skin without scales	Scales
Breathing		Lungs	Lungs	Lungs	Gills in early life when living in water; lungs when adults on land	Gills
Reproduction		Young born alive and nourished by milk from the mother	Eggs	Snakes, by eggs or by young born alive; turtles, by eggs	Eggs, hatching to become tadpoles, which later become adults	Eggs (usually) Fins, but no legs
Special Adaptations		Most have four limbs with which to walk, run, climb, or swim	Two wings (usually) and two legs	Shells on turtles; snakes, without legs, crawl or swim; turtles, with legs, walk or swim	Most live in water in early life, then on land	

Animals without Backbones. We learned earlier that grasshoppers are covered by a tough outer skin that gives shape to their bodies. This skin is really an outside skeleton, taking the place of a backbone and an internal skeleton. All insects, crayfish, spiders, clams, snails, earthworms, and many other simple types of animals have no backbone or other inside skeleton. All of these are cold-blooded, too. Because insects, crayfish, and spiders have jointed legs, they are classified as joint-footed animals.

Let us review the characteristics of insects, described in detail in chapter 1. All insects have the body divided into three main

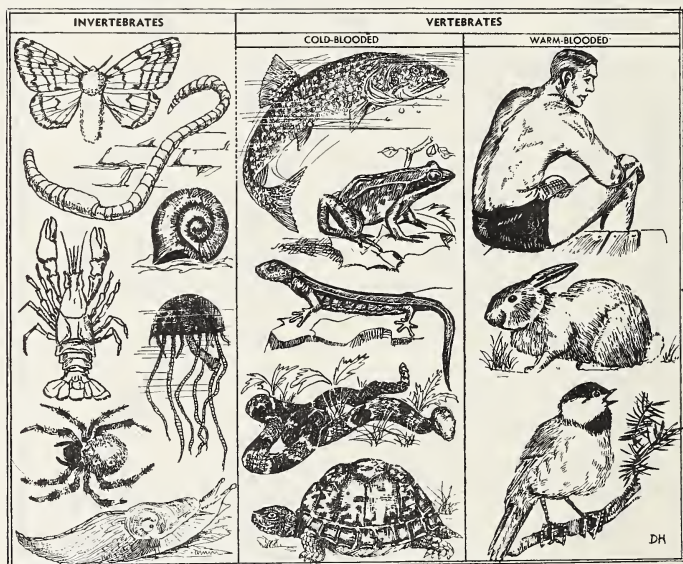


FIG. 4-5. THE ANIMAL KINGDOM.

In the left column, find each of the following animals without backbones (invertebrates): gypsy moth, earthworm, snail, crayfish, jellyfish, garden spider, slug.

In columns two and three are drawings of several animals with backbones (vertebrates). Find the following cold-blooded vertebrates: lake trout, wood frog, red-backed salamander, rattlesnake, box turtle—also the following warm-blooded vertebrates: man, rabbit, chickadee.

parts and have three pairs of legs. Most insects have two pairs of wings, although flies and mosquitoes have only one pair, and a few insects have no wings. All insects have a pair of feelers and a pair of compound eyes. Insects breathe through small pores along the sides of the body. The life history of most includes the three stages we described for grasshoppers, namely, egg, nymph, and adult, or the four stages characteristic of house flies, namely, egg, larva, pupa, and adult.

Spiders differ from insects in having only two main parts to the body and four pairs of legs. Crayfish and lobsters have two main parts to the body and several pairs of jointed legs. Centipedes and millipedes have many pairs of legs.

Many animals without backbones do not have jointed legs. Clams, snails, oysters, and slugs all have soft bodies, those of the first three being protected by a shell. Earthworms have elongated, slender, soft bodies; so have many smaller and simpler kinds of worms, some of which live on land, some in water, and some inside the bodies of man or other animals.

In addition to all these types of animals, there are many others without backbones, including jellyfish, sponges, corals, and numerous one-celled animals.

Man's Place among Living Things. Think of all the different kinds of geographical conditions under which man lives. In polar regions, he ekes out an existence where ice and snow are round him most of the year; in tropical regions, he withstands intense heat with extremes of both dryness and moisture; in temperate regions, favoured by a more moderate temperature and a medium amount of rainfall, he has developed the highest levels of civilization. We may well ask why man has been more successful than other forms of life in adapting his ways of living to the wide range of conditions throughout the world, and in controlling his environment, to a limited degree, to serve his purposes.

Many animals act according to their environments. Frogs swim when in water and jump when on land. Cats and dogs often show that they want to come inside when the weather is

cold or stormy. Like man, many animals have the power of memory. But man has a mind, and he can think and reason. This power helped early man to learn how to defend himself from wild animals that were swifter and more powerful than he, and sometimes had keener senses of sight and smell.

Man's intelligence places him on a higher level than any other living thing. It has enabled him to find new and better ways of living. The invention of language by the human race has enabled man to convey his ideas from person to person, both orally and in writing. In the Stone Age, man learned how to use flint to make spearheads and simple knives and tools. Having mastered the use of fire, he learned how to make bronze from copper and tin, and how to smelt iron. With these metals, he fashioned new kinds of tools, implements, and machines that served him better. Man's power of invention carried him through the Stone Age, the Bronze Age, and the Iron Age to the present age of electricity, aeroplanes, and atomic power.

Throughout the ages, man has learned more and more about how to use plants and animals to satisfy his needs for food, clothing, and shelter. Early man hunted wild plants and animals for use as food and clothing. Man became a herdsman when he learned that he could tame wild cattle, sheep, and horses and keep them under his control to serve him. At a still later time, man became a farmer when he learned how to cultivate the soil and raise crops of wheat and other grains instead of depending upon wild grass as feed for his stock.

In modern living, human beings depend upon mammals to a large degree. Horses, camels, and dogs work for us; cattle and goats give us milk, which we use as food in various forms; the carcasses of sheep, cattle, and swine become our meat. Mammals supply raw materials for our manufacturing industries and, therefore, help to provide many essential products. Leather is made from the hides of pigs, cows, sheep, and horses; woollen clothing is made from the wool of sheep; and furs are processed from the hides of many fur-bearing animals living in the open or reared on our fur farms. In our research laboratories we use guinea pigs, rats, mice, rabbits, and monkeys.

Man's powers of thinking, planning, reasoning, experimenting, inventing, and of choosing the better ways of doing things, all expressed in the word science, have steadily enabled him to adapt himself more and more to the varying conditions of temperature and of other geographical factors in his surroundings, and to control them for his service. Man learned how to adapt himself to adverse conditions of weather and climate by inventing new textiles and building materials for his clothing and homes. He conquered mountains and streams by constructing tunnels, digging canals, and building dams and power plants.

With his knowledge of modern science, man has learned how to control many diseases that once caused frequent epidemics. In agricultural colleges and experimental stations, he has worked to improve the world's food supplies by creating new varieties of grains, fruits, and vegetables, and better types of livestock, also by showing the way to new and better methods of draining, irrigating, cultivating, and fertilizing the soil. We learned much about this in *General Science*, Book 1, chapters 20 and 21, and we shall continue the study in chapter 23 of this book.

Things To Do

1. Make a survey of your neighbourhood and report the conditions observed that may help to spread disease.
2. Using the following headings, make a table to compare the characteristics of insects with those of birds: skeleton, legs, wings, body covering, locomotion, temperature, reproduction, breathing.
3. Name three plants that (a) make their own food, (b) get their food from decaying vegetation, (c) get their food from other living plants.

Test Questions

1. What precautions should be taken to prevent disease bacteria from spreading (a) on the playgrounds, (b) in school, (c) from a sick person to healthy people in the same home.
2. What characteristics distinguish living things from non-living things?

3. How do animals differ from plants in (a) their ability to move, (b) their methods of obtaining nourishment, (c) reproduction?

4. Why can fungi not make their own food? Why can they live in the dark?

Your Word List

Fungi, chlorophyll, bacteria, germicide, communicable disease, warm-blooded, non-living, intelligence.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Queer Plants That Have To Steal Their Food", Vol. M, pp. 455-457.

16 mm. Sound Films

Ontario Visual Education Branch

Tiny Water Animals (microscopic) (SN-78)

What Is Science? (scientific method) (SG-32)

Animal Movement (SN-5)

Life of a One-Celled Animal (SB-3)

National Film Board of Canada

The World at Your Feet (colour)

Film Strips

National Film Board of Canada

Pioneer Life in Upper Canada

5

INSECT FRIENDS AND FOES

SOME INSECTS are our friends; others are our mortal enemies. Which of these groups they belong to depends largely upon their habits of living and eating. Those that make valuable products or render useful services to us are, of course, our friends, while those that eat or destroy the living things or goods that we raise or produce are our foes. Therefore, to understand any insect in relation to our interests, we must learn about its habits, preferably by first-hand observations in its natural environment.

Insect Friends

Insects that are our friends serve us by making food for us, by supplying raw materials for clothing, by controlling other insects that are harmful to us, and by pollinating some of our plants and thus enabling them to produce fruits and seeds.

The Honeybee. The writings of man from earliest times show that he has prized the honeybee because of its gifts of honey and wax. Man first obtained these products by cutting the hollow trees in which the bees lived, and robbing them of their stores. Before 4,000 B.C. man had domesticated bees by supplying

them with homes, probably hollow logs, in which they could live and store their honey. For the last hundred years beekeepers have used hives with movable frames.

See figs. 1-3, 1-4, 1-5, and 1-6 for a review of the honeybee's ways of living.

The bees of Canada make enough honey to give every man, woman, and child three pounds a year. Honey was the most common sweet before sugarcane was discovered and used. Most honey is served as food. As well as being used on the table, honey is used in general cooking, in the preparation of sweets by confectioners, and in the making of medicines. Because about three-fourths of it is sugar, honey is not only easily digested, but is one of our best energy-producing foods. Honey also contains minerals, vitamins, and water.

Honey varies widely with the kinds of flowers that provide the nectar. If made from clover or basswood, it is very light in colour and of excellent flavour, but if made from buckwheat, it is usually quite dark and less palatable.

Honey is marketed in the comb, as extracted honey in pails or jars, and as honey butter.

In yet another way, bees are friends to man. Without bees there would be no fruit, and very few garden flowers could produce seed. As a bee reaches for the flower's nectar, some of the pollen sticks to her hairy body (fig. 1-6). When she alights on the next flower, at least a little of the pollen is likely to be rubbed against this flower's sticky stigma. As a result of this pollination, fruits and seeds are produced.

The Bumblebee. The bees frequently seen visiting red clover blossoms are bumblebees, originally called humblebees (fig. 5-1, G). Though they are seeking nectar and pollen for food, they accidentally carry some pollen from flower to flower, making seed production possible. The bumblebees' feeding tubes are long enough to reach the nectar deep down in the tubes of clover flowers. Honeybees are unable to reach this nectar and seldom visit these flowers. For this reason farmers are dependent

upon the bumblebees for red clover seed. Most of the seed is obtained from the second cutting, because bumblebees are more numerous late in summer.

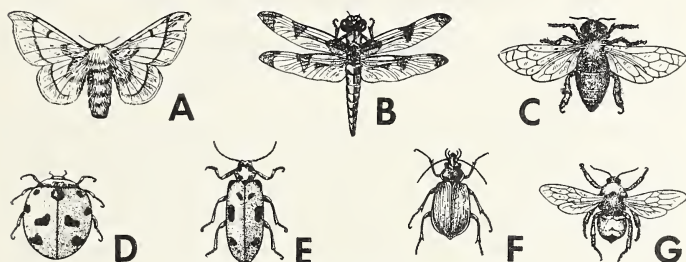


FIG. 5-1. SOME BENEFICIAL INSECTS.

A, silkworm moth; B, dragonfly; C, honeybee; D, ladybird beetle; E, milkweed beetle; F, ground beetle; G, bumblebee.

The Silkworm. Silk has long been our most luxurious textile, and the raising of silkworms has been carried on in the Far East for more than 3,000 years. It seems worthwhile, therefore, to find out how so important an insect as the silkworm is reared in Japan, the leading silk-producing country of the world.

Carefully selected silkworm moths (fig. 5-1, A) are raised in strictly inspected institutions. Here, each moth lays about 400 eggs. The eggs are stored, then distributed to farmers who grow mulberry trees to provide leaves as food for the silkworms.

A farmer may buy 30,000 to 40,000 eggs, a total weight of an ounce. He usually takes them to a public incubator where they hatch in approximately 10 days, producing silkworms—the larval stage in the insect's life.

The young silkworms are cared for indoors where temperature, light, and cleanliness are controlled. The caterpillars from an ounce of eggs, fed every three hours or so, eat three-quarters of a ton of mulberry leaves in a month. In about five weeks the silkworm larvae have moulted four times and are ready to spin their cocoons and become pupae. The farmer sells the cocoons within two weeks, before the moths can emerge.

In the silk-reeling plants, the cocoons are heated to kill the

pupae, then soaked in hot water to loosen the strands of silk. The silk from several cocoons, usually five, is twisted into one thread as it is unwound. Later, the raw silk is washed, twisted into heavier strands, dyed, and woven into cloth.

The Dragonfly. Dragonflies have always served as man's allies in waging war against harmful insects, especially flies and mosquitoes.

There are several kinds of dragonflies, some larger, and some more beautifully marked than others. You will see them most commonly in June and July as they dart over sun-lit ponds. Their four lacy wings, moving "an average of twenty-eight times a second", carry them through the air as fast as a mile a minute. Their keen sight and their ability to dart and turn go hand in hand with their great speed. No wonder dragonflies can catch and eat so many mosquitoes and other insects!

Dragonflies lay their eggs in water as they skim over its surface, touching it with the ends of their bodies. The eggs hatch into nymphs which lack wings and are not at all graceful as their parents are (figs. 5-1, B and 5-2). The nymphs live among reeds and grasses in the water. Here, they lie in wait

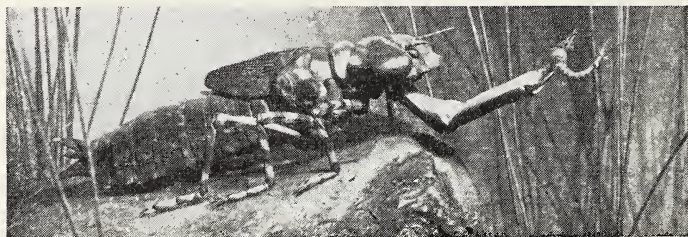


FIG. 5-2. A DRAGONFLY NYMPH CATCHING A MOSQUITO LARVA.

In this photograph of an enlarged model, find the partially developed wings, the three pairs of legs, the breathing pores, the eyes and antennae, and the long, jointed lower lip with which the nymph seizes prey.

in their hiding places, watching for small water animals, especially the larvae of mosquitoes. These they dart after, seize with their long, jointed lower lips, and eat. Because the nymphs live under water, they breathe by gills. As they grow larger,

they moult periodically. The nymph stage lasts for two or three years. Then the nymph crawls out of the water onto a plant stem or other support. Here, its outer coat dries and splits open, permitting it to emerge as a full-grown adult dragonfly. After the dragonfly has dried its wings, it flies away, no longer an ugly water creature, but an object of delicate beauty.

Give a dragonfly a pond, bright sunshine, and plenty of living insects, and it will work happily in the interests of man.

The Ladybird Beetle. Ladybird beetles are found on most plants, especially wherever plant lice live. Although there are several kinds of ladybird beetles, each looks like a tiny pill cut in half, with legs attached to the flat surface. All have spots of some kind on their backs, sometimes red or yellow on black, and sometimes black on red or yellow. Like grasshoppers, ladybird beetles have a pair of hard front wings which serve as protective covers for the thin, soft back wings which are used for flight. The life history of ladybird beetles consists of four stages, egg, larva, pupa, and adult.

Ladybird beetles are one of man's most helpful allies, both as adults and as larvae. As soon as larvae hatch, they seek aphids and other small insects, especially scale insects, as food. Before their final moult, the larvae have eaten many times their weight in insects, mostly those injurious to man's crops. The adults continue throughout their lives to rid plants of aphids and other injurious insects. In some places, ladybird beetles are collected or imported by governments and distributed over farm lands to help control insect pests.

Test Yourself

1. In what ways are bees useful to man?
2. How do bees and flowers form a partnership?
3. State three reasons why honey is a good food?
4. Nectar contains 80% water and 20% sugar. Honey contains 20% water and 80% sugar. How many pounds of nectar are needed to make a pound of honey?
5. Remove some of the separate little flowers from a head of red clover and examine them. How is a bumblebee adapted to pollinate these flowers?

6. Describe the life history of silkworms raised indoors commercially.

7. How are dragonfly nymphs and adults similar in their feeding habits? How are they different?

8. Why would you be justified in collecting ladybird beetles in fields and bringing them to your garden?

9. Try to name the beneficial insects illustrated in fig. 5-1.

Insects Foes

Insects live by the millions wherever man goes, and many of them are his enemies. Some insects bite man; some sting him; some steal his food or prevent plants from making it for him; some attack his domestic animals; some destroy his household goods; and others carry disease germs from person to person. Unless man keeps up a successful warfare against injurious insects, he will almost certainly be driven from the earth by starvation and disease. Therefore, it is important that we understand what harm is done by some of our commonest insect pests, and how we can control them.

The House Fly. Perhaps the most common insect to bother human beings and to threaten their health is the house fly. It is found wherever we live, and it is with us from early spring until late autumn, sometimes even in winter. Because the adaptations of this insect for survival are so wonderful, its habits so loathesome, and the danger from it so real, yet so frequently ignored, we should study its ways of living and the relation of these to our health in order that we may more successfully wage a war to exterminate it.

Adaptations and Harmful Habits of House Flies. House flies are effective carriers of germs that cause typhoid fever, cholera, dysentery, and infantile or summer diarrhoea. Most of their habits and structures fit them well for this unwelcome practice.

PUPIL INVESTIGATIONS. *Observe the habits and the adaptations of living house flies.*

1. Observe house flies flying, turning quickly, and alighting. How many wings have they? Notice how rapidly the wings move and what makes them strong and light.

2. Test the seeing power of house flies by trying to catch one from the side, from behind, and from above. Examine the screen-like surface of the two large *compound eyes* (like those in fig. 1-9), which shows that they are made up of thousands of tiny parts, each of which can see straight out from it. Look for three tiny, black, shining *simple eyes* on the top of the head.

3. Place a little sugar, a few drops of fruit juice, and a little milk in different bottles. Catch some flies and put one or more in each bottle. Observe how they crawl on smooth glass and how they walk when upside down. See how the flies take in liquid food, and how they dissolve the sugar before taking it in.

When a fly alights on exposed cubes of sugar or at the edge of the milk on our cereal, and when it sits impertinently on a plate beside our meat course, or sips sweet sauce from our pudding, it may have just returned from another meal in a garbage pail or a manure pile. In any case, it probably brought a load of filth and a million or so germs with it, adhering to its hairy body or the hairy pads on its feet.

The fly may have come considerable distance, for its wings, although only two in number, beat so rapidly that they carry it with ease. Its sense of smell

guides it to the inviting aromas of the kitchen or dining room. On arrival, the fly may alight anywhere, for its sharp claws grip any rough surface, and the two sticky, hairy pads on each

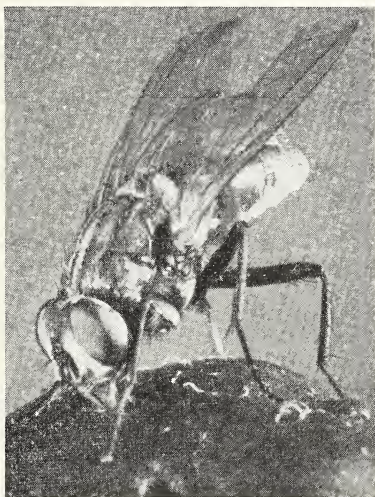


FIG. 5-3. A COMMON HOUSE FLY FEEDING.

Find the sucking mouth, the large compound eyes, the three pairs of legs and two pairs of wings, and the many hairs on the body and legs.

foot keep it from slipping from any smooth surface, even when it is in an upside-down position. See fig. 5-4.



FIG. 5-4. THE HAIRY PADS AND CLAWS OF A FLY'S FOOT.

See the filth on the hairs and on the sticky covering of the two pads between the claws—and think of the germs there, too!

The table manners of a fly are as advantageous to it as they are disgusting to us. Its two large compound eyes, somewhat like those of a grasshopper, enable the fly to see a couple of feet away and guide it to the chosen dish. Its three tiny simple eyes, capable of seeing an inch or so, direct it to the food itself. If this is liquid, the fly merely sucks it in through its mouth, modified to form a sucking tube. To obtain nourishment from solid

food, the fly first applies to it a liberal covering of saliva, then sucks up the dissolved food.

While the fly satisfies its hunger, many of the germs it brought with it fall from its hairy body and feet into the food it leaves for us. Here, the bacteria grow and multiply, often causing the food to deteriorate, and sometimes infecting it with the germs of communicable diseases.

The extremely rapid multiplication of house flies and the filthy nature of their usual breeding places increase their power to do harm. A female fly may lay more than a hundred eggs at a time and repeat the operation several times in her short life. About nine-tenths of the time she chooses to lay the eggs in manure; the balance of the time, in other decaying vegetable or animal matter or filth. In a few hours the eggs hatch into white larvae. Because these are legless, they are called *maggots*. These feed voraciously for five or six days, then their skins thicken and darken until they look like grains of wheat. The larvae have become pupae. Although the pupae appear to be resting, they are really very active within, for the wings, legs,

and sucking tube characteristic of the adult fly develop in less than a week. When the skin of a pupa breaks, a full-grown adult fly crawls out and flies away, ready to lay eggs in 10 days or so and start another generation.

House Flies Should Be Exterminated. We help to eradicate house flies when we swat them, catch them with sticky fly paper, or kill them with sweetened liquid containing poison. We keep them from our food when we see that all doors and windows are effectively equipped with screens. It is still better to do away with them entirely. When we eliminate the breeding places of house flies, we prevent new generations from coming into being, and the adult flies round about us die a natural death in a few days or weeks. If manure is removed from stables and spread in fields at least twice a week, and if garbage pails are always kept covered, very few flies will have an opportunity to lay eggs where maggots can feed, and even fewer maggots will survive long enough to become pupae.

Answer These

1. How can each of the following help to exterminate house flies: a fly swatter, fly papers, fly poison, removing barnyard manure at least twice a week, keeping garbage covered?

2. How can each of the following help to keep house flies from spreading disease: clean surroundings, screens on windows and doors, keeping food covered?

3. How is a house fly fitted to walk on smooth surfaces, to fly and dart about quickly, to see where to alight, to see its food while eating, to take in liquid food, to eat solid foods?

The Mosquito. Mosquitoes have long been a nuisance to man. They fast during the day among bushes and shrubs, then come forth in the evening to satisfy their hunger—as most of us have been made well aware.

Strange as it may seem, mosquitoes do not really bite. True, we have all watched a mosquito leave us, laden with our blood, and have immediately seen the white swelling where it worked. We have examined the tiny opening it left in the skin, and felt the itchy sensation. All the mosquito did was to insert its long,

slender, tube-like beak, something like a hypodermic needle, through the skin, suck up some blood, and leave a small amount of saliva in the wound. Only female mosquitoes sting or draw human blood. During their very short life, male mosquitoes are content to feed on the sap or nectar of plants.

Life History of Mosquitoes (An Activity for Spring)

PUPIL INVESTIGATIONS. *Raising a mosquito family.*

Look into tin cans or other water containers out of doors for raft-like masses of mosquito eggs, also for wrigglers and pupae. If you do not find these, place a dish of water on the outside window sill where mosquitoes may lay their eggs in it.

Place the eggs, wrigglers, or pupae in a tumbler of water. Cover this, and observe the development of the young mosquitoes. How do the wrigglers travel, feed, and breathe? Watch for the change of shape as a wriggler becomes a pupa. You will know the pupa by the way it pushes its shoulders out of the water. How does it get air? Keep notes showing the dates of changes from eggs to wrigglers and from wrigglers to pupae. Compare what you have seen with what is shown in fig. 5-5.

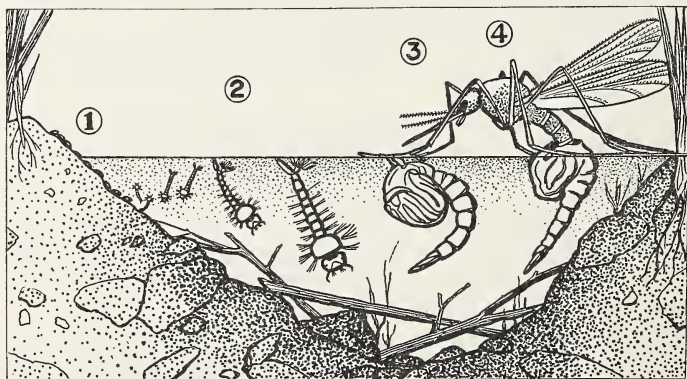


FIG. 5-5. LIFE STAGES OF A COMMON MOSQUITO.

(1) Eggs, in this instance laid on the ground; (2) larvae (wrigglers), two of them with their breathing tubes at the surface of the water; (3) a pupa in breathing position; (4) an adult emerging from the pupa case.

Mosquitoes lay their eggs in various places. The kind commonly found in woods lays its eggs in hollows in autumn. Both spring thaws and spring rains fill these hollows with water in which the eggs hatch into little wrigglers. The common house mosquito lays its eggs on the surface of stagnant water in eaves-troughs, tin cans, or pools. The female mosquito rests on some object just at the surface of the water and launches her little raft of eggs, each egg like a little upright cartridge, and all glued together in a waterproof mass.

The eggs may hatch the same day, or perhaps as late as four days after, depending upon the temperature of the water. A wriggler, as the larva is called, travels by wriggling, feeds by brushing tiny water creatures into its mouth, and breathes by means of a breathing tube on the tail. This tube is held at the surface of the water while the head hangs downwards.

The pupa is almost all "head and shoulders". It can still wriggle about when it chooses, but it seldom chooses. Because its two breathing tubes are behind the head, it must keep its shoulders at the surface of the water when it is not swimming. Within the outside covering of the pupa, the wings, legs, and mouth parts of the future adult are developing. When these are full-grown, in two to four days, the adult breaks through the back of the pupa case, rests on this as on a canoe, dries its wings, and flies away. Half a day later, it is ready for its first meal.

Harm Done by Mosquitoes. The mosquitoes that we know are, to say the least, pests. Other kinds, not present in Canada, are more harmful, for some of them spread *malaria* and *yellow fever*.

Malaria is a disease accompanied by high fever and chills. For the most part, it attacks people living in low, swampy places in warm countries.

Scientists discovered the relation of mosquitoes to the spread of malaria in three stages. First, they found tiny, colourless creatures in the red corpuscles of malaria patients. Twenty years later, Dr. Ronald Ross, working in the swamps of India,

discovered similar tiny creatures in mosquitoes' stomachs. Experiments showed that birds bitten by these mosquitoes took malaria. When a London scientist permitted himself to be bitten by mosquitoes sent from the malaria-infested swamps of Italy, he, too, took malaria. Through this and other similar tests it was proven that malaria is spread only when this particular kind of mosquito bites first a person suffering from malaria, and then a well person. To get rid of malaria, we have only to get rid of the particular kind of mosquito that is responsible for its spread.

Yellow fever, like malaria, is carried from person to person by yet another kind of mosquito. The building of the Panama Canal had to be discontinued because of the ravages of yellow fever among the workmen. Later it was learned that only mosquitoes can spread yellow fever. By controlling these, the U.S. Government was able to complete the canal, and scientists have been able to make yellow fever a disease of the past.

Control of Mosquitoes. Mosquitoes must have water in which to lay their eggs. Therefore, we should see that all pails, tubs, and barrels that contain water are screened to keep mosquitoes out. We should see, too, that there are no water containers, such as blocked eaves-troughs and old tin cans, in which the eggs may be laid. Some swamps and marshes in which mosquitoes breed may be drained.

We cannot prevent the mosquitoes from laying eggs in other bodies of still water, but we can prevent the wrigglers and pupae from living long.

PUPIL INVESTIGATIONS. *Will kerosene keep mosquitoes from breeding?*

In two glass jars partly filled with water place several mosquito wrigglers and pupae. To the water in one jar add a few drops of kerosene. What effect has the kerosene upon the breathing of the wrigglers and pupae?

Kerosene poured on the surface of water forms a thin film which prevents the wrigglers and pupae from getting their

breathing tubes out to the air. As a result, the wrigglers suffocate. A tablespoonful of kerosene is enough to cover a barrel of rainwater. In summer, ponds must be sprayed weekly with kerosene or fuel oil if mosquitoes are to be kept under control.

To rid a camp or a tent of mosquito pests, we may use dense smoke, smudges, or sprays. To keep mosquitoes from biting the face and arms, oil of citronella may be rubbed on.

Things To Do

1. Make a survey of your district to discover in what places mosquitoes breed. Destroy as many of these breeding places as you can.
2. Find out what method, if any, is used by the local municipality to control mosquitoes.

Answer These

1. In what three ways can mosquitoes harm man?
2. Why do we in Canada not get malaria or yellow fever when a mosquito has bitten us?
3. How does kerosene or fuel oil sprayed on stagnant water control mosquitoes?

Aphids or Plant Lice. Aphids are often found on house plants, flowering bulbs, garden flowering plants, and roses. They are likely to be most numerous on young leaves, the tender tips of stems, and opening flowers, but may also live on roots. Aphids are recognized by their small size and pear-like shape. In colour, they are usually green, but may be red or black.

PUPIL INVESTIGATIONS. *Observe aphids at work on leaves.*

Examine leaves of house plants or garden plants bearing aphids. A hand lens will be helpful. Try to find aphids eating. How do they get their food? Look for their little tube-like mouths pressed against the leaf as they suck in sap. See fig. 5-6.

How do aphids move about? Do any of them have wings? How many legs have they? Do they use their feelers while walking? If so, how?

Look for aphids of different sizes—some large, some small. You may see empty skins cast off by moulting.

Feeding Habits. An aphid spends its life sucking sap from whatever part of the plant it lives on. Having pierced the skin of the plant with its sucking tube, the little insect sits and drinks

until it decides to move to another spot. Then it withdraws the tube, folds it back under its body, moves a few steps, and starts the process over again.

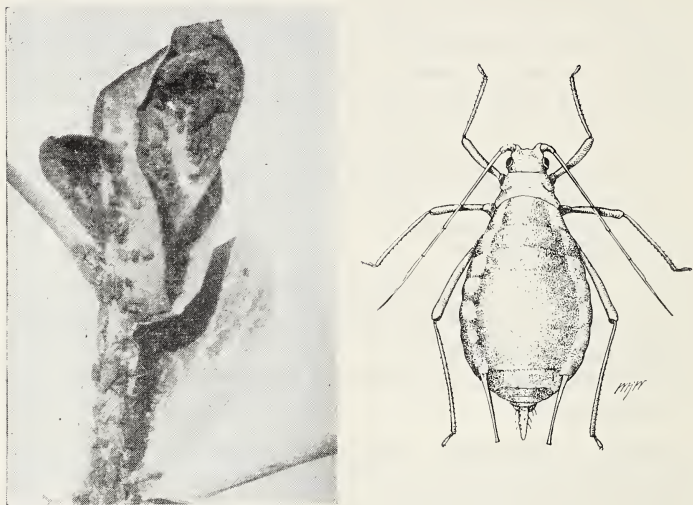


FIG. 5-6. APHIDS ON A PEA PLANT.

Left, aphids of various sizes sucking juices from the leaves and stems; right, an enlarged drawing of a pea aphid, showing its pear-shaped body, three pairs of legs, feelers, and eyes.

Life History of Aphids. In spring, the first aphids come from eggs that survived winter. Throughout the summer, young aphids that resemble their parents, but are smaller, are born alive and soon grow to maturity by feeding voraciously and moulting from time to time. In autumn, the adult aphids lay eggs which remain dormant over winter.

Harm Done by Aphids. Aphids rob a plant of the sap containing its food. This reduces the growth of the plant, especially the growth of its flowers and fruits. As aphids increase in numbers and take more sap, the plant may die.

Control of Aphids. Fortunately, aphids have natural enemies, especially ladybird beetles. Both the larvae and the adult

ladybird beetles seem to prefer aphids to any other insect for food. Man's most effective method of controlling aphids is to spray the plants thoroughly with a solution of nicotine sulphate, then repeat the treatment in three or four days.

Test Questions

1. How does the colour of green aphids protect them?
2. How do aphids harm plants?
3. What natural enemies have aphids?
4. How can we destroy aphids on our house plants?

Other Injurious Insects

In addition to the injurious insects described above, many others cause much harm or loss to mankind. Several species attack our garden vegetables and house plants. When they eat foliage or suck sap from leaves, these pests reduce the vegetable crop and make our ornamental plants unsightly in appearance and stunted in growth. Other insects reduce, injure, or destroy field crops by feeding upon their foliage, stems, or roots. Most forest and shade trees have their insect enemies. These either devour some of the foliage and reduce its power to make food, or they steal ready-made plant foods in the sap. In both cases the insect pests interfere with the normal growth of the trees or cause their death. Fruit growers suffer financially when insects attack either the foliage, the trunks, or the fruits of their orchard trees.

Some insects take their toll of growing plants. Others attack or destroy man's stored crops and livestock, his meats and other processed foods, his clothing and household goods, and even man himself.

Insects Injurious to Garden Plants.

Cabbage Butterflies.

Adult butterflies whitish; larvae green, eat holes through the leaves and into the heads of cabbage and cauliflower.



FIG. 5-7.

Control: hand-pick larvae; dust or spray plants with DDT or lead arsenate.

Radish and Onion Maggots. White, legless maggots that burrow into onion bulbs and radish roots.

Control: wet the soil around the plants with corrosive sublimate solution.

Cutworms. Dull-coloured caterpillars that cut off the stems of cabbages, tomatoes, and flowering plants near the surface of the ground at night.

Control: put collars of tarpaper around plant stems at the soil level; place poisoned bait of bran and paris green on the soil before planting or around each plant.

Tomato Worms. Caterpillars large, green, and hairless, with V-shaped markings; eat foliage. See fig. 5-17.

Control: hand-pick larvae.



FIG. 5-8.

Ants. These destroy grass and garden plants by building nests among or close to them.

Control: use syrup or peanut butter poisoned with paris green, or commercial ant pastes and poisons.

Insects Injurious to Field Crops.

White Grubs (June Beetles). Large, white or light-yellow grubs, usually curved (A); feed on potato tubers and the roots of many plants for two or three years; adult beetles (B) eat foliage at night.



FIG. 5-9.

Control: eaten by skunks and some other animals; spade or plough the ground in autumn; rotate crops; spray trees.

Wireworms (Click Beetles). Slender, yellow to white, "wiry" worms; puncture and tunnel stems and roots.

Control: rotate crops; avoid planting corn or root crops on newly ploughed sod; cultivate in fall.

Colorado Potato Beetles. Beetles with black and yellow stripes (right); larvae red with black markings, soft (left); both eat potato foliage.

Control: hand - pick adults; dust or spray plants with calcium arsenate, paris green, or DDT.



FIG. 5-10.

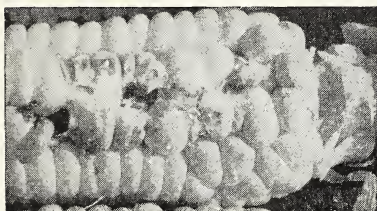


FIG. 5-11.

European Corn Borers. Small, dirty-white caterpillars; feed in stalks and ears of corn and cause stems to break. *NOTE*. See the larva (borer) just emerging from the black hole at the lower left of fig. 5-11.

Control: destroy all crop refuse by feeding, burning, or ploughing it under before May 20.

Insects Injurious to Shade, Forest, and Orchard Trees.

Apple and Forest Tent Caterpillars. Eggs laid in collar-like cylinders around twigs in autumn; larvae hairy with a white stripe or spots down the centre of the back, feed on foliage, and live in tent-like webs like that shown in fig. 5-12.

Control: eaten by birds, wasps, amphibians, and others; burn the webs, including the caterpillars; spray trees with DDT or lead arsenate at budding time.

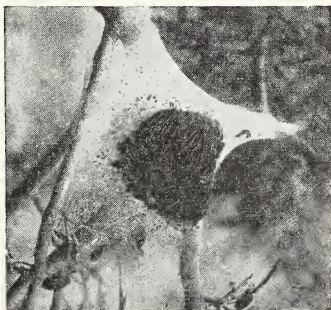


FIG. 5-12.

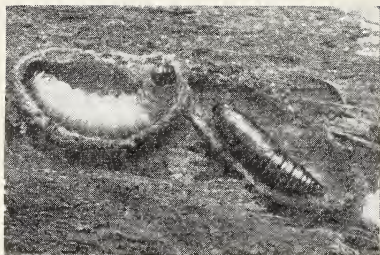


FIG. 5-13.

Codling Moths (Apple Worms). White caterpillars, common in apples; cause apples to fall early; tunnels ruin fruit for market. Fig. 5-13 shows larva (left) and pupa (right) in bark.

Control: eaten by some birds; spray young leaves and fruit several times with lead arsenate or DDT.

Insects Injurious to Man and Other Animals.

House Flies and Mosquitoes. See description on pages 88 to 91.

Stable Flies. Smaller than common house flies; bite horses and cattle.

Control: as for house flies.

Horse Bot Flies. Resemble honeybees; buzz about the heads of horses; larvae live in the stomachs of horses.

Control: apply fly spray to horses' legs where eggs are laid.

Poultry Lice. Usually found on the head and under the wings and tail; bite the flesh and feed on bits of feathers and skin; reduce egg production. Fig. 5-14 shows three kinds.



FIG. 5-14.

Control: sprinkle sodium fluoride dust among opened feathers; spray roosts with nicotine sulphate; provide a dust bath.

Poultry Mites. Suck blood from poultry.

Control: keep poultry houses clean; spray the interior with coal oil; whitewash walls and equipment.

Insects Injurious to Household Goods.

Cockroaches. Prefer kitchens and pantries; hide in warm, dark, damp, narrow spaces and come out in the dark; travel from filth to food.

Control: keep conditions sanitary; dust shelves with sodium fluoride or DDT powder.

Silverfish. Small, silver-white, wingless insects; usually found among books or starched material; damage books, carpets, clothing.

Control: mix DDT powder in starch paste on a card and leave it where they will find it, or sprinkle it in cracks.

Clothes Moths. Commonest in dark closets; moths lay white eggs in clothes; larvae destroy clothes, bedding, and furniture as they eat woollens, fur, and hair.

Control: dry-clean clothes or expose them to sun and air before storing; store clothes in paper bags and tight closets with dichloricide crystals, moth balls, or naphthalene; fumigate.

Buffalo Carpet Beetles. Adult beetles blackish; larvae covered with long, brown hairs; feed in carpets, rugs, and furs.

Control: shake from rugs; fumigate; spray with kerosene.



FIG. 5-15.

Insects Are Man's Greatest Rivals

Insects compete with man for many of this earth's goods. Many characteristics of insects make them such strong competitors that man will soon be without food or home or clothing unless he uses every weapon available to keep the hordes of insects under control.

As we have already learned, insects outnumber all other forms of animal life. Some are fitted to live in nearly every kind of condition, wet or dry, cold or warm. Insects are found wherever there is suitable food, whether it be in living plants or animals or in their many products. They always seem to be hungry, and they have such enormous appetites for their size that they would soon destroy the food of man's livestock and of man himself, if not controlled.

Most insects multiply so rapidly that they are an immediate threat whenever even one pair appears. A pair of house flies or aphids in early summer could well be the forerunners of a million, million, million flies or aphids by autumn if all survived their enemies.

Insects have many ways of protecting themselves. Some caterpillars are so hairy that few birds will eat them. Others are distasteful to insect-eating birds and other animals. Because bees and mosquitoes pierce the skin of their victims and inject an irritating substance, people and other animals are more likely to avoid them.

Insects are becoming more and more difficult to kill. Less than 10 years ago, house flies were easily killed by DDT. In many places where this insecticide has been used a great deal, the present generations of flies are not killed by it. This change has come about because, as time went on, the flies that survived DDT continued to produce new generations, each becoming less affected by this chemical. We say the flies have become *immune* to DDT.

When we consider the many characteristics that make them a threat to man's welfare, it is not to be wondered at that insects are such dangerous rivals of man in seeking to dominate the earth.

Insects Must Be Controlled

No insect has been known to disappear from the earth because of man's activities, although some have been done away with in certain areas. For example, the Colorado potato beetle has been eradicated in England for periods of 30 years or more, but occasionally reappears.

Chemicals that kill insects are known as *insecticides*. Some insecticides are called *stomach insecticides* or *stomach poisons* because they kill insects only when swallowed by them. Such insecticides are applied to foliage where insects with biting mouth parts are likely to feed. Paris green is a stomach insecticide often sprayed on potato leaves to kill Colorado potato beetles. Similar stomach insecticides are used to kill insects that eat the foliage of grapes, cabbages, and fruit trees.

A solution of nicotine kills aphids when it wets their bodies. For this reason it is called a *contact insecticide*. DDT works in this way.

Moth balls give off a gas that kills clothes moths when they breathe it. Insecticides of this nature that give off vapours or

gases that kill insects when taken in through the skin or with the air they breathe are called *fumigants*.

Aerosol bombs are a recent invention to control mosquitoes and house flies. The insecticide is stored in a metal container under pressure. From this it is sprayed as a gas into the air to kill insects.

Many aeroplanes are now being used to combat such insects as mosquitoes, grasshoppers, and forest insect pests. As early as 1927, insecticide was dusted on trees on Cape Breton Island, Nova Scotia, in an attempt to control spruce budworm.



FIG. 5-16. SPRAYING FRUIT TREES IN NIAGARA PENINSULA.

Stomach insecticides are used to kill insects that eat foliage; lime sulphur is used to control fungus diseases.

Livestock are protected from annoyance and injury by insects when insecticides are sprayed forcefully into the hair or wool. Insects on orchard and forest trees and on vegetables are controlled by liquid chemicals from powerful sprayers or by powders dusted on the foliage.

Insects were among the first stowaways on sailing ships, and are still frequent stowaways in modern ships, trucks, cars, trains, and aeroplanes. Many injurious insects have been brought into a country or a district accidentally with living plants and animals in baggage, in packing materials, and even in the mails.

Quarantine laws require careful inspection of goods in transit to keep out harmful insects not yet in our country .

Insects have natural enemies such as bats, birds, skunks, moles, frogs, toads, snakes, and fish—even other insects. Ladybird beetles and dragonflies eat numerous injurious insects. Some special insects, called parasites, lay their eggs in the bodies of large caterpillars; then the larvae from these eggs gradually kill the caterpillar in which they live and feed. See fig. 5-17.



FIG. 5-17. TOMATO WORM BEARING
COCOONS OF ITS PARASITES.

The small, oval, white objects on the back of the caterpillar are cocoons, spun by tiny larvae that lived in the caterpillar's body.

Insects, like other animals, are attacked by diseases. Some of these spread rapidly from insect to insect and kill off large numbers in a short period of time. Unfortunately, such diseases are as likely to kill friendly insects, such as honeybees and silkworms, as they are to attack such insect enemies as house flies and grasshoppers.

Weather, unfavourable to certain insects, may be man's ally in keeping them under control. Late, wet springs reduce the numbers of grasshoppers; early fall frosts kill white grubs near the surface of the soil; and cold weather slows down the rate of multiplication of flies and mosquitoes.

Good housekeeping and sanitation help to control such household insects as house flies, clothes moths, cockroaches, ants,

silverfish, and carpet beetles. Keeping kitchen cupboards and pantries clean, and removing garbage, bits of food, and pieces of waste fabrics reduce the amount of food available for these insects and deprive them of places in which to hide and multiply.

Things To Do

1. Make a class collection of insects that are useful and of insects that are harmful. Label each insect with its name and a brief statement of its use or harm.

2. Collect and display parts of plants damaged by insects. Label each with the name of the plant and the name of the insect.

3. Find a leaf bearing aphids. Count the number of these plant lice per square inch of leaf surface and estimate the total number on the plant.

4. Make a survey of all closets in your home where no provision has been made to repel or kill clothes moths. Examine woollen or flannel clothing, blankets, and hats for evidences of moths. Destroy all adult moths or larvae; brush the clothing well; hang it out in the sun and air; and put it back with some moth remedy.

Answer These

1. State six characteristics of insects that make them such formidable enemies of man.

2. Name two injurious insects that have biting mouth parts and two that have sucking mouth parts. Tell how each insect is harmful to plants or animals.

3. What is meant by stomach insecticide, contact insecticide, fumigant? Give an example of each.

4. State three ways in which insects are protected from their enemies, and name one insect protected in each way.

5. Give four characteristics of insects that cause them to be called animals.

6. Mention six general methods of controlling insects.

Your Word List

Injurious, beneficial, wrigglers, maggots, aphid, pollinate, malaria, dominate, insecticide, fumigant, nicotine, kerosene.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "The Mosquito—Always a Pest—Often a Killer", Vol. M, pp. 400-404; "The Marvels Hidden in an Anthill", Vol. A, pp. 253-257; "Insect Champions in the Struggle for Survival", Vol. B, pp. 103-108; "Insect Pests That Cost Man Billions of Dollars Yearly", Vol. IJ, pp. 162-165; "Our Clever Friends—the Wasps", Vol. WXYZ, pp. 49-53.

*16 mm. Sound Films**Ontario Visual Education Branch*

Swat the Fly (H-21)

Life of an Ant (SN-7)

The Mosquito (SN-52)

House Fly (SN-40)

Moths (life histories and economic studies) (SN-53)

National Film Board of Canada

Vegetable Insects (colour) (also available from Ontario Visual Education Branch)

The Warble Fly and Its Control (colour).

6

BIRDS IN RELATION TO MAN

MOST BIRDS ARE OUR GOOD FRIENDS AND HELPERS. Some serve us well, but also do some harm. A few seem to do more harm than good. To judge birds fairly, we must learn to understand their ways of living. Then we should do all we can to help deserving birds.

Most Birds Help Us

Birds rank next to our domesticated animals in giving us pleasure and in rendering us service. The world around us would seem dull indeed without the bright colours and the cheery songs of our busy, happy bird friends. Were it not for them, man would have a much harder battle to wage against the myriads of injurious insects that attack his crops and stock, and the weeds that impoverish his soil.

Birds Give Us Pleasure. Before birds come within sight, we enjoy their sweet songs, their friendly twitterings, and their familiar calls. How silent our gardens would be in springtime without the "cheerily, cheerily, cheerup, cheerup" of the robin; our clumps of shrubs, without the "sweet, sweet, sweet, merry, merry, merry" of the song sparrow; our pastures, without the



FIG. 6-1. How Birds Serve Us.

A, a song sparrow singing for our enjoyment; B, a flicker feeding on ants where they are getting honeydew; C, a snow bunting feeding on weed seeds; D, a gull flying over water, searching for refuse; E, a herring gull feeding on garbage.

whistle-like “spring o’ the year” of the meadowlark; and the woods, without the choruses of various melodies. We welcome birds, too, for their bright and beautiful colours and plumage, and for their graceful movements, whether they be flying, hopping about, building their nests, feeding their young, or splashing in water. Indeed, we take pleasure in observing and studying the interesting habits of birds and in trying to judge from their notes and actions whether they are contented or fearful, pleased or angry, modest or vain. The better we become acquainted with birds, the more we feel and appreciate these aesthetic values.

Birds Control Insect and Mammal Pests.

Birds are man’s most helpful allies in his efforts to control injurious insects. Without his bird helpers, man would almost certainly fail to keep in check the numerous insect pests that attack his garden and field crops, his orchard and forest

trees, his livestock, and even himself. As we have already discovered in chapter 2, birds are well adapted to serve man in this way. Their keen sight, their remarkably constructed feet and bills, and their power of flight enable birds to find

and catch insects in almost every kind of place—on trees and other vegetation, in the ground, and in the air. The voracious appetites of both the adults and the rapidly growing young enable birds to devour insects in unbelievable quantities. See fig. 6-2.



FIG. 6-2. BIRDS CONTROL INSECTS.

A, a starling carrying a May beetle to its young; B, hungry young robins begging to be fed.

No matter where insects live, on trees or in them, there are birds on their trail. Insects on trunks and branches are taken by chickadees, nuthatches, woodpeckers, and brown creepers; those on leaves and blossoms are devoured by warblers, vireos, tanagers, orioles, and many other birds.

In summer and winter the cheery little black-capped chickadees peck into every crack and crevice of the trunks and branches of trees for the eggs, larvae, chrysalids, and adults of tiny insects. In summer they inspect the foliage just as closely. Small as they are, chickadees eat with ease 200 to 500 insects a day in one stage or another.

On the trunks and branches near the chickadees we often find white-breasted nuthatches clinging in all sorts of positions, even upside down, and prying away loose bark to find and eat the insects and their larvae hiding beneath it.

Any insects that escape the keen eyes of the chickadees and nuthatches are likely to fall prey to downy woodpeckers and their larger cousins, the hairy woodpeckers. From the surface of tree trunks and branches these birds pick off scale insects; from

bark crevices they pull out the eggs, larvae, pupae, and adults of many insects, but specialize in devouring the larvae of codling moths; from the wood they dig out wood-boring beetles and grubs. As we learned in chapter 2, the feet, bills, and tongues of woodpeckers equip them well for this service to trees and to man. Review fig. 2-8,B.

When the brown creepers arrive from the south to spend the summer with us, they help the chickadees, nuthatches, and woodpeckers to rid the trunks of trees of harmful insects. As their name implies, brown creepers creep spirally up the sides of trees, probing with their long, slender, curved bills into every nook and crevice for hidden insects. When a brown creeper has eaten all the tiny eggs and sleeping pupae it can find on one trip up a tree, it flies to the foot of the same or another tree and begins another upward search.

Fortunately for owners of shade trees and orchards, the chickadees, nuthatches, and woodpeckers continue their valuable services even in the coldest winter weather.

A pair of wrens have been observed to make 30 trips an hour to bring insects, singly or by the beakful, to their nestlings—and they do this from dawn until dusk. The same procedure is repeated when these birds raise a second family and, perhaps, even a third, and all the while the adults and young grown-ups are eating insects, too.

Many birds spend a lifetime catching and eating insects that live in or on the ground. Important among such birds are meadowlarks, robins, bluebirds, bobolinks, and gulls. Meadowlarks and bluebirds search fields for grasshoppers, crickets, cutworms, and other harmful insects. It has been said that the daily menu of a meadowlark may consist of 100 cutworms, 100 grasshoppers, 200 ground beetles, 50 caterpillars, and 2,000 weed seeds. Much of the food of bobolinks and robins also consists of insects from the ground, most of which are injurious to man's crops. One robin was known to eat 165 cutworms in one day. The stomach of one flicker was found to contain 5,000 ants (fig. 6-1, B). In Salt Lake City there is a monument to the gulls that rid

an early settlement in that region of a plague of black crickets that had destroyed one crop and threatened the next.

Many birds feed upon insects caught in flight. Swallows, swifts, nighthawks, whip-poor-wills, phoebes, kingbirds, wood pewees, and flycatchers obtain most of their food in this manner. House flies, mosquitoes, grasshoppers, and beetles are included in their diet. The stomach of one nighthawk contained 300 mosquitoes. Even the flies about the feet and backs of cattle in fields are snatched away by cowbirds.

What would happen if we did not have the birds to help control insects? The insects would multiply so rapidly that they would devour all the vegetation in our fields, our orchards, and our forests. There could then be no livestock, no food for man, and soon no man.

Some birds serve farmers and orchard owners well by devouring harmful rodents such as field mice. Chief among these bird helpers are the hawks and owls. They keep up a round-the-clock search for mice, the hawks by day, and the owls chiefly by night. The importance of these birds will be discussed more fully later in this chapter.

Birds Destroy Many Weed Seeds. Besides the many injurious insects, there are other thieves in the fields—the weeds. Many of our common birds eat large quantities of weed seeds. In summer, canaries, goldfinches, song sparrows, and chipping sparrows are constantly at work devouring the seeds of weeds. In winter, snow buntings, tree sparrows, juncos, and quail search for weed seeds above the level of the snow. Two records will emphasize the large quantities of seeds destroyed by birds: one bobwhite (quail) was known to have eaten 1,700 weed seeds in one meal, and the stomach of a snow bunting was found to contain 1,500 seeds of pigweed alone. The strong, stout bills of the seed-eating birds are well adapted to pick and, when necessary, to crush the seeds. Then digestion destroys most of them. See figs. 6-1,C and 20-1.

Birds Have Other Values. Birds are useful as scavengers, as game, and as food. Because they clear refuse from the trails of ships and from along shorelines, flocks of gulls are an efficient

Some Beneficial Birds

Name of Bird	Where Usually Found	Chief Food
Baltimore Oriole	Tall trees, especially elms	Chiefly caterpillars, beetles, ants, grasshoppers; a small amount of wild fruit
Bluebird	Orchards, gardens, cavities in trees, nesting boxes	More than three-quarters insects: grasshoppers, beetles, caterpillars; some berries, mostly wild
Bobolink	Meadows and fields	Largely insects in spring and summer, and weed seeds in autumn; much rice in the south
Brown Creeper	On tree trunks	Almost entirely insects
Chickadee	Around homes and gardens, on small branches of trees and shrubs	Practically all injurious insects; some weed seeds
Flicker	Dead trees, telephone poles, lawns	Mostly injurious insects, including many ants; some weed seeds
Goldfinch	Orchards, gardens, shade trees, weed patches	Almost entirely weed seeds
Junco	Usually on the ground among weeds	Mostly weed seeds; some insects
Kingbird	Orchards and roadsides	Mostly insects caught in flight; some wild fruit
Meadowlark	Meadows and pastures, especially near water	Three-quarters insects: grasshoppers, beetles, caterpillars, crickets; many weed seeds and a little grain
Nuthatch	Limbs and trunks of trees	Nearly three-quarters injurious insects hidden in the bark; about one-quarter weed seeds
Red-winged Blackbird	Around water, especially marshes	Three-quarters weed seeds; some corn, wheat, and oats; some insects
Robin	Lawns, gardens, orchards	About two-thirds insects, chiefly harmful beetles, grasshoppers, and caterpillars some fruit, mostly wild

Name of Bird	Where Usually Found	Chief Food
Snow Bunting	Among the tops of weeds above snow	Seeds only
Song Sparrow	Shrubby and thickets	About half weed seeds; remainder insects, chiefly injurious beetles, weevils, and grasshoppers, and some wild fruit
Swallows	Cliffs, eaves of buildings, abandoned nests, bird houses	Almost entirely insects, caught chiefly in the air or picked from tall plants
Woodpeckers (hairy, downy, and red-headed)	Trunks of living and dead trees, also on poles and posts	Mostly injurious insects from bark and wood
House Wren	Around homes and gardens and in bird houses	Almost entirely insects, such as grasshoppers, beetles, caterpillars, and bugs; also spiders

garbage-collecting organization. In the Yucatan (Central America) the killing of many shore birds that had been devouring refuse was followed by a higher disease rate among the people. See fig. 6-1, D and E.

To the pioneers, wild game birds such as quail and grouse were one of the few sources of meat. These, with wild ducks and wild geese, still provide good sport, recreation, and food. See fig. 6-3.



FIG. 6-3. MALLARD DUCKS AT HEART LAKE, PRINCE ALBERT NATIONAL PARK, SASKATCHEWAN.

Some Native Wild Fowl

Name	Recognition and Habitat	Habits	Value to Man and How Protected
Quail or Bobwhite	Grey and brown like dead grass; found only where protected; lives in open spaces and fields, and on roadsides; calls "bob-white"	Nests on ground; scratches for food; roosts in trees	Eats potato beetles and, in winter, weed seeds; is fed grain under shelters; reared on game farms
Grouse or Partridge	Like a small greyish-brown hen; prefers wooded places	Burrows in snow; "drums" with wings; nests on ground; young very active	Devours weed seeds and insects, especially grasshoppers; game birds, providing sport for man
Wild Ducks	Several kinds; neck thrust forward when flying; live along waterways	Eat water plants; nest usually on the ground in grass near water	Provide food and sport; domestic ducks developed from wild mallard duck
Canada Goose	V-shaped flight formation; honking sound	Nests on ground; breeds farther north; eats vegetable food	Provides sport and food
Ring-necked Pheasant	Male has white collar and showy colours; found on ground in field or wood; nests in grass	Strolls among fields	Eats insects, grain, and seeds; a valuable game bird

Let's Help the Birds

We should help the birds for our own sake as well as theirs. When we protect the birds, we make certain that they will continue to destroy harmful insects and weed seeds and, at the same time, make our surroundings more interesting to us. If we go one step further and make our surroundings more attractive for our bird friends by providing them with protection, food, and safe nesting places, more birds will come where they can work for us and add to our enjoyment.

In trying to protect and attract birds, we must remember that they are timid creatures. Until they learn to understand our motives, they seem to have an instinctive fear of people—often with cause. It follows that we must use the utmost caution in trying to help birds or to tempt them to come close to our homes. Otherwise, we may make them even more suspicious.

Certain rules must be accepted and obeyed by all before commencing plans to attract birds to our homes or schools. On no occasion should anyone throw a stone or a stick at a bird. Guns and sling-shots should never be taken near the nesting or feeding areas of birds. The nests of birds, and the trees, grass, and other sites where they build nests, must never be disturbed.

The methods by which we can help or attract birds vary with the kinds of birds and, therefore, with the seasons. In summer, we can expect only the permanent residents and the summer residents; in winter we have the permanent residents and the winter residents that have come temporarily from farther north.

Birds Need Our Help. Birds are subject to many hazards. The most common are: unfavourable weather conditions; natural enemies that attack birds; and surroundings that are unfavourable for protection, nesting, and food. Unfavourable weather conditions and the enemies that attack birds are so much a part of nature that we can render the birds little relief except by providing food, shelters, and nesting boxes. Other hazards facing birds are so much of our making, or are so largely under our control, that we can remove or greatly reduce them.

Scarcity of food is probably the greatest hazard faced by birds in winter. Insects that live in the air in summer are not there in winter, and those that live in the ground are not available after freeze-up or when the ground is covered with snow. Most weed seeds are buried by snow in winter, with the exception of those on tall stalks projecting above snow level. When snow is covered by a crust, the difficulties facing birds become still

greater. Layers of ice on trees keep such insect-eaters as woodpeckers, nuthatches, and brown creepers from getting at insects in or beneath the bark. Yet it is when the temperature is low and the wind biting that birds need most food to keep their bodies warm.

Man has unwittingly increased the difficulties of birds. By cutting forests and clearing shrubs, bushes, and long grass from fence rows, man has removed many of the birds' safe nesting sites and natural means of protection, and has destroyed much of their natural food. By cutting down hollow trees, burning brush and dry grass, and draining swamps, he has destroyed their nesting places and, often, their eggs or young.

If we are to have our birds with us in such large numbers that they will continue to rid our crops and orchards of injurious weed seeds and insects, we must take steps to protect birds from their enemies, help them obtain sufficient food of the right kind, and provide them with safe living quarters.

Provide Birds with Safety from Their Enemies. The domestic cat is the worst enemy of birds. Each cat is thought to kill a yearly average of fifty song birds—particularly nestlings and young birds learning to fly. We can keep cats from molesting nesting birds by placing metal cylinders around the poles that support bird houses or around the trees that harbour birds' nests (figs. 6-8,C and 6-10,D). The tops of these metal guards should be about four feet from the ground. However, if cats are well fed, they are less likely to hunt birds.

Not least among birds' enemies are the unappreciative or thoughtless people who shoot them, and who disturb their



FIG. 6-4. A BULLSNAKE EATING THE LAST OF NINE EGGS IN A BIRD'S NEST.

nests. Recognizing the need of protecting birds against man, Canada, the United States, and Mexico have agreed (through the "Migratory Birds Convention Act") to protect migratory birds while they are in their breeding grounds in the north, and while they are migrating to or through the south. It is illegal to "kill, hunt, injure, take or molest any migratory birds during the close season", to take the nests or eggs of any migratory bird, or to buy or sell any migratory game bird.

Some of the natural enemies of birds are snakes, crows, weasels, minks, foxes, red squirrels, and a few hawks. Perhaps, in some ways, it is fortunate that we cannot protect birds from most of these foes. Doubtless, the weakest, the least alert, and the most poorly adapted birds are destroyed by their enemies. As a result, the stronger and better equipped birds of each variety tend to survive and produce new generations of higher-quality birds.

Provide Birds with Food and Water. The surest way of making birds happy and contented enough to stay with us is to give them water for drinking and bathing and food to satisfy their hunger.

Birds drink often and bathe once or twice a day. A lack of drinking and bathing accommodation keeps many birds out of cities and towns in hot, dry weather. To attract them, we should place bird baths some distance away from bushes so that the birds are less likely to be raided by prowling cats. There should be no more than two inches of water in the deepest part of the vessel, and just



FIG. 6-5. TREE SPARROWS VISITING A CONCRETE BIRD BATH IN WINTER.

one-half inch at the edge. The bottom of the bath should be rough so that the birds will not slip. A basin or the cover of a garbage pail attached to the top of a post or sunk into the ground with its edge at ground level makes a satisfactory bird bath. A more permanent one may be made by digging a depression into the ground and lining it with concrete and pebbles. The bird bath is useless unless there is always clean water in it. Birds need water in winter, too, but it should be warm and placed in the sun.

To plan a bird-feeding project, we must understand the feeding habits of the birds we wish to help. Insect-eating birds, such as brown creepers and woodpeckers, like suet. Chickadees and nuthatches are partial to nuts and sunflower seeds, but they also like crumbs and suet. Sparrows, juncos, and other seed-eaters prefer to eat on the ground and will come to get bread crumbs, cracked or whole grain, chicken feeds, or barn-floor sweepings scattered in places free from snow and, preferably, under evergreen trees, discarded Christmas trees, or some cover that will protect the feeding birds from unfavourable weather conditions. Although



FIG. 6-6. BIRDS THAT VISIT OUR FEEDING STATIONS.

A, a white-breasted nuthatch in characteristic position on a tree; B, a slate-coloured junco looking for seeds; C, a cedar waxwing resting after feeding on berries; D, a downy woodpecker in drilling position; E, a blue jay in noisy action; F, an evening grosbeak.

blue jays seem to prefer nuts, seeds, and suet, they will also take bread.

Feeding birds is easy and interesting whether you use simple methods or prepare special feeding devices. For chickadees, nuthatches, and woodpeckers, suet may be nailed or tied to a post or to the underside of tree branches, or it may be hung out in a woven or crocheted bag or in a coconut. See fig. 6-7. For seed-eaters, crumbs and grain may be placed under a box with one side removed, and with the opening turned away from the wind.

A feeding tray or a bird lunch counter a square foot or more in area may be constructed with a tight floor and a protecting edge two or three inches high on three sides. This may be attached to a window ledge or a pole suspended from



FIG. 6-7. A DOWNY WOODPECKER FEEDING ON SUET HELD BY CHICKEN WIRE.

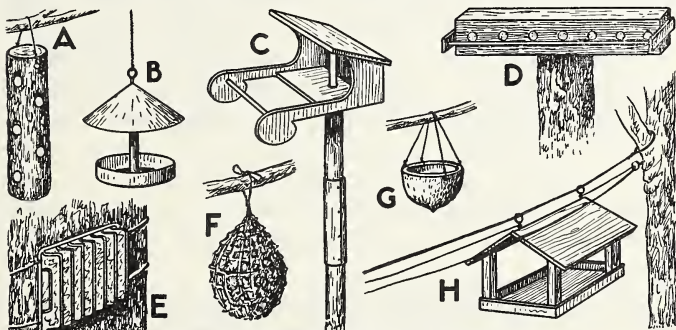


FIG. 6-8. BIRD FEEDING STATIONS.

A, a log with holes for suet; B, a squirrel-proof feeding tray; C, a covered feeding tray free to turn so that the open side is away from the wind; D, a "birdstone" lunch counter; E, suet in a soap dish tied to a tree; F, a mesh bag filled with suet; G, half of a coconut; H, a trolley-type feeding tray that may be pulled to the house to have food placed on it.

a branch of a tree. Of course, birds prefer natural-looking feeding stations with rough, weathered surfaces rather than smooth, painted ones.

A feeding station may be made by boring holes in all sides of a small block of wood a foot or two in length and filling the holes with suet or a mixture of melted suet and seeds. This "stick" should be hung where visiting birds are safe from their enemies and easily observed. A "food tree" may be prepared for birds by pouring a mixture of melted suet and seeds, crumbs, and nuts over the branches of a discarded Christmas tree. Study fig. 6-8 for more ideas.

All feeding devices should be placed where the birds obtain some protection from unfavourable weather conditions and from such natural enemies as cats. Feeding trays should open towards the south or should be attached to the south side of a building. Metal guards should be placed on trees or poles supporting bird feeding devices so that cats cannot prey upon the feeding birds.

Game birds, such as pheasants, grouse, and quail, prefer grain. For these birds we can leave out stooks or ears of corn or sheaves of grain, or we may place mixed grain under such natural windbreaks as clumps of evergreen trees, shrubs, grape-vine tangles, fallen logs, or under specially constructed shelters.

To encourage birds to stay with us instead of going elsewhere because of scarcity of food, we should begin our feeding programme in late October. Once started, feeding should be continued throughout the winter, for birds soon learn to depend upon our help and, without it, might starve for lack of knowledge of other feeding places. Birds that arrive from the south in early spring may suffer from cold or lack of food unless we feed them, too.

Many birds depend upon the berries and other fruits of wild trees and shrubs for food. Summer residents eat the fruit of red-berried elder, common (black-berried) elder, grape, blackberry, raspberry, mulberry, cherry, plum, and rose. Permanent and winter residents often feed upon fruits that remain on plants in autumn and winter, including those of honeysuckle,

bittersweet, barberry, dogwood, and hawthorn. The seeds of hemlock, cedar, and other evergreen trees are eaten by birds with thick strong beaks, including sparrows, cedar waxwings, crossbills, and goldfinches. Many seed-eating birds like the seeds of birch trees. Sumach fruits are acceptable to several species of birds throughout the year.

Unfortunately, man has cut away many of the fruit-bearing wild trees and shrubs in his effort to grow more farm crops. This has made it harder for birds to find wild fruits. Little wonder some birds occasionally take fruit from cultivated trees!

We can help both the birds and ourselves by conserving wild fruit-bearing trees and shrubs and by planting cultivated varieties for the birds. Among plants that would improve the appearance of home grounds and also provide food for our bird friends are mountain ash, Japanese barberry, red-berried elder, Virginia creeper, honeysuckle, and mulberry. Some of these are illustrated in fig. 6-9.

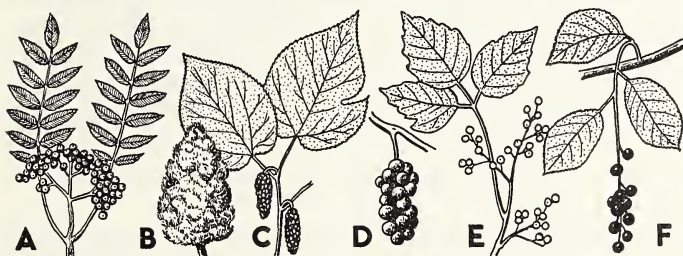


FIG. 6-9. FRUITS THAT BIRDS EAT.

A, mountain ash; B, sumach; C, mulberry; D, wild grape; E, poison ivy; F, choke cherry.

Things To Do

1. Around a tree or the school flagpole, about 4 feet from the ground, make a bird lunch counter about 8 inches wide and edged with a barrel hoop. Keep the counter free from snow and place dinner scraps on it for birds.

2. Feed birds in some of these ways: make hanging baskets from the skins of halves of oranges or grapefruit, fill them with food, and hang them on trees; tie balls of suet mixed with small nuts on trees

at home or in the schoolyard; stuff cones of evergreen trees with melted suet and tie them to trees.

3. Make a bird feeding tray and attach it to a post, a tree, or the outside of a window.

Provide Birds with Nesting Sites, Nesting Houses, and Nesting Materials. When man cleared and cultivated the land, he deprived birds of many of their naturally protected breeding places. The pioneer removed trees, bushes, and long grass; the modern farmer has done away with brush heaps, hollow stumps, and old rail fences; the market gardener has drained marshes. All of these changes have increased the need of birds for suitable nesting sites, nesting houses, and nesting materials. We can help birds in the following ways: by establishing bird sanctuaries in which their natural home sites will be undisturbed; by leaving trees, shrubs, brush, and long grass in fence corners and waste places; and by planting trees around our homes.

By making and putting up bird houses, we give birds protected places in which it is easy for them to build their nests. Bluebirds, chickadees, flickers, robins, English sparrows, wrens, and martins will use nesting houses. Woodpeckers and nuthatches prefer homes in hollow trees. Shelves, shelters, or open boxes are the choice of robins and phoebes. Barn and eave swallows appreciate knot holes or other openings left as entrances into barns.

We should think of each bird house as especially prepared for only one or a few species of birds. Each bird has its particular habits of building nests and its own requirements with respect to space. Therefore, it is important to study the habits and the size of the particular bird to be attracted before planning to build a house for it.

Bird houses can be made by anyone who can use a saw, a hammer, and nails. All that are needed are materials such as weathered pieces of scrap lumber, slabs or pieces of bark, old shingles, roofing paper, hollow logs, tin cans, and hollowed-out coconuts. These are sufficient to make many types of nesting houses.

Bird houses must be so constructed that they keep the birds comfortable. Each house should have weather-tight roof and walls, a floor that is drained, openings under the roof for ventilation, a space of suitable size for the nest, and an entrance hole of the correct size for the bird. A hinged cover is convenient for spring and fall housecleaning.

Study fig. 6-10 as you read further.

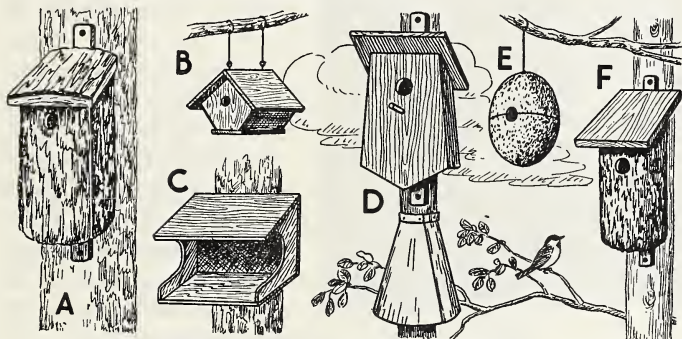


FIG. 6-10. NESTING HOUSES FOR BIRDS.

A, a slab house for woodpeckers; B, a home for wrens; C, a protected shelf for a robin's nest; D, a bluebird house protected by a cat guard on the post; E, a coconut nesting box for wrens; F, a log-type nesting box for chickadees.

Nesting houses are commonly of two types: those that resemble hollow trees or limbs, and board houses. A house of the first type is easily made by cutting a hollow log of the right diameter to the correct length, making the entrance for the bird, and attaching the base and a sloping top. A house made of slabs, or of boards covered with bark, resembles a hollow-log house. Either of these is suitable for woodpeckers or flickers. Board houses may be made for bluebirds, wrens, or chickadees. They should be made of weathered wood, or should be stained or painted to look like an old tree trunk. Houses for wrens may be made of various materials: coconuts, gourds, or large flower pots. A flower-pot bird house is made by drilling an entrance hole in the side of the pot and attaching a cover over the open rim of the pot.

The placing of a nesting house is as important as its construction. Unless the house is erected early enough, the would-be

tenants will have moved into other homes. For chickadees, the sign "To Rent" should be up by February 1st. The entrance to a nesting house should always be turned away from the prevailing winds. Houses for the fearless wrens may be near dwellings; those for the timid bluebirds (fig. 6-11), some distance away from buildings; and those for martins, far enough from trees to give the birds space in which to swoop.

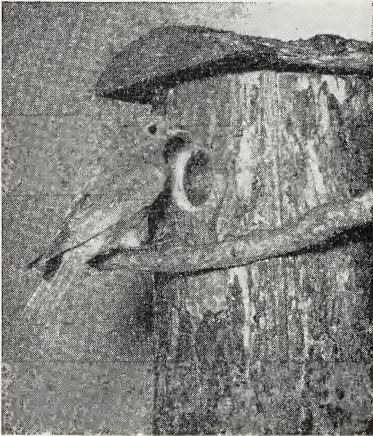


FIG. 6-11. A BLUEBIRD AND HIS SLAB HOUSE.

Table of Bird House Dimensions

Bird House for	Inside Size of Floor	Inside Depth	Distance of Entrance above Floor	Size of Entrance Opening	Suitable Height above Ground
Bluebird	5" x 5"	8"	6"	1½"	7' to 15'
Robin (nesting shelf)	6" x 8"	8"	Open	Open	6' to 15'
Chickadee	4" x 4"	7" to 10"	6" to 8"	1⅛"	6' to 15'
House Wren	4" x 5"	6" to 10"	6" to 8"	1⅛"	7' to 20'
Martin	6" x 7"	6"	1"	2½"	16' or higher
Hairy Woodpecker	6" x 7"	12" to 15"	11"	1½" to 2"	12' to 20'
Downy Woodpecker	4½" x 4½"	8" to 10"	8"	1¼"	8' to 20'

Materials with which birds may make their nests should be left on fences or shrubs where birds can easily see and get them. Orioles, chickadees, and vireos will use yarn, string, or bits of cotton; house wrens will use bits of sticks to build their nests; and robins use straw and dried grass. If mud is left in a pan out of doors, robins and swallows will use it to make the plaster for their homes.

Things To Do

1. Search for winter feeding-places for birds. Visit meadows, fence corners, and roadsides. List the kinds of weeds, wild fruit trees, and shrubs that contain food for birds in winter. Collect, mount, and label specimens of some of these plants. Name the birds you find feeding on them.

2. Encourage farmers to leave long grass, wild fruit trees, and shrubbery in fence corners as a means of protection and as a source of food for birds in winter.

3. List the main hazards of our winter birds and, after each, state how nature or man helps to overcome this hazard.

4. Make a robin's nesting shelf and use it as a feeding station in winter.

5. Make one of the bird baths described in this chapter and place it on the lawn at your home or your school.

6. Prepare a collection of string, yarn, hair, and other nesting materials and place it where birds are building nests. Observe how birds use the materials.

7. Organize a bird club and take part in some of these activities: identifying birds, taking a bird census of the locality, building bird houses, building bird feeding stations and shelters, setting up a library containing books and pamphlets on protecting and attracting birds.

8. From a window watch birds contentedly preening their feathers, drinking, and bathing — and feel the glow of happiness that comes from entertaining the birds.

Birds on Trial

Give Hawks and Owls a Fair Trial. Half a century ago, in Scotland, several counties were so over-run by field mice that nearly every growing plant was destroyed. The testimony of

large numbers of farmers and shepherds showed that the cause of the increase in the number of mice was the destruction of hawks, owls, and other natural enemies of the mice. So thick were the mice that one man with his dogs destroyed fifteen thousand in a month.

Then came large numbers of short-eared owls. They remained and reproduced rapidly. So successfully did they and the hawks control the mice that a committee of the British Board of Agriculture finally reported: "It would be difficult to condemn too severely the foolish action of those who allow or encourage the destruction of hawks and owls."

Are hawks and owls chiefly beneficial or injurious in Canada today? Whether any bird is harmful or helpful depends largely upon what it eats. If it eats the crops man raises, it is considered harmful; if it eats animals that harm crops, it is considered beneficial. Let us examine evidence, then, to decide how we should classify hawks and owls.

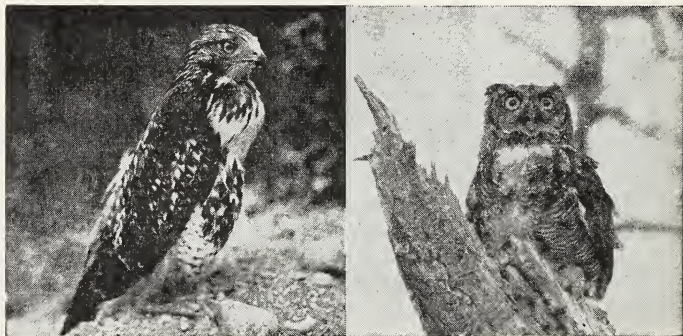


FIG. 6-12. MOST HAWKS AND OWLS ARE BENEFICIAL.

A, a red-tailed hawk, the food of which is approximately 90% mice and other harmful rodents; B, a great horned owl, largely beneficial, but taking some poultry.

A hawk that attacks poultry commits an offence against the poultry owner. However, we cannot decide whether the hawk does more harm than good until we know what else it eats.

Scientists obtain definite information about the food of a particular kind of hawk by examining the contents of the stomachs of several birds of that species. Such stomach examinations have led scientists to conclude that of our best known hawks only the goshawk, Cooper's hawk, and sharp-shinned hawk should be considered harmful. Of more than 1,300 stomachs of other common hawks examined, only 5% contained poultry or game birds, but 60% contained mice and other small mammals, and more than 30% contained insects, mostly injurious. From this evidence, we can safely conclude that most hawks do much more good than harm and should be protected.

Are most owls beneficial or injurious? The table entitled "Food Chart of Owls" provides the evidence on which we may answer this question. It shows you that the food of the larger owls consists largely of rodents, chiefly mice, and that the food of the smaller owls is largely insects. Only a very small part of the food of owls is made up of poultry or birds. We may conclude from the table that none of the owls are actually harmful and that all but a few of the larger species are almost entirely beneficial.

Food Chart of Owls

	Rodents	Insects	Poultry	Birds	General Rating
Barn Owl	90%	5%		5%	Beneficial
Great Horned Owl	80%	5%	10%	5%	Beneficial
Screech Owl	55%	40%		5%	Beneficial
Short-eared Owl	90%	10%			Beneficial
Barred Owl	90%	5%	2%	3%	Beneficial
Snowy Owl	70%		10%	20%	Beneficial

Courtesy General Biological Supply House, Chicago

The control of mice by hawks and owls is very important to agriculture. When farmers are harvesting hay or grain, they frequently find mice nests made of grass and containing from

four to eight young field mice—and these are only one of the five or six families the same parents may have raised during the summer. One adult mouse eats its own weight in stems, roots, and grain each summer day, or about 25 pounds a year. In addition, it continues its harmful work by gnawing the bark from fruit trees (girdling them) in winter. Consider how numerous mice would be, and how harmful to farmers, if hawks and owls did not take up the task of keeping them in check, the hawks by day and the owls by night.

Yes, it is the duty of all of us to use our influence to see that hawks and owls, the friends of farmers, are given the protection they need and deserve.

Consider These Estimates of Naturalists

1. "An owl eats approximately 1,000 mice a year, saving for the farmer 10 or 11 tons of vegetation."
2. "Each hawk and owl around a farm is worth about \$20.00 a year in saving crops from mice."
3. "Hawks and owls are at least 70% beneficial."

Things To Do

1. Make a collection of pictures of different kinds of hawks and owls, then attach to each picture a list of things that each bird eats, underlining those that make up most of its food.

2. Make a poster entitled "Give Hawks and Owls a Fair Trial."

Other Birds That Do Harm. In addition to the hawks mentioned above, a few other birds are more or less injurious. Some birds rob or interfere with the nests, eggs, and young of beneficial birds. Cowbirds lay their eggs in the nests of other birds and thus have their young hatched for them. Blackbirds interfere with the nests of other birds. Although crows eat the eggs of other birds and also feed on freshly planted, sprouting corn and grain, they do good by eating grasshoppers. House sparrows chase swallows from barns, bother wrens, usurp the nesting

boxes of bluebirds and martins, and eat grain—but they also eat weed seeds. Shrikes kill a number of beneficial birds, but they do good by eating injurious insects and rodents. Starlings often gather in business and residential areas in such large numbers that they become a serious nuisance.

Things To Do

1. Investigate the feeding and other habits of the following birds, then discuss in class what attitude we should take towards them: crows, shrikes, starlings, house sparrows, great horned owls, and pigeon hawks.

2. Make and erect bird houses where birds will not be afraid to use them. Keep a record of your bird "tenants".

3. Make illustrated posters bearing one or more of the following titles: "Ceiling Cleaners" (showing such birds as swallows, swifts, nighthawks, flycatchers, and phoebes catching insects in the air); "Furniture Cleaners" (showing chickadees, warblers, nuthatches, and woodpeckers on trees, shrubs, and low plants); "Carpet Cleaners" (showing sparrows, quail, pheasants, meadowlarks, flickers, and goldfinches feeding on the ground); "Sink and Drain Cleaners" (showing sandpipers and ducks in waterways); "Destroyers of Vermin" (showing owls and hawks eating rats and mice); "Garbage Cleaners" (showing gulls, crows, and sparrows eating refuse).

Read and Discuss

Think of your woods and orchards without birds!

Of empty nests that cling to boughs and beams . . . !
Will bleat of flocks or bellowing of herds

Make up for the lost music, when your teams
Drag home the stingy harvest, and no more

The feathered gleaners follow to your door?
You call them thieves and pillagers; but know

They are the winged wardens of your farms,
Who from the cornfields drive the insidious foe,

And from your harvests keep a hundred harms;
Even the blackest of them all, the crow,

Renders good service as your man-at-arms,
Crushing the beetle in his coat of mail,

And crying havoc on the slug and snail.

Longfellow, "The Birds of Killingworth"

Your Word List

Beneficial, injurious, pests, seed-eating, scavengers, aesthetic, conserving, nesting sites.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Our Charming Neighbors in Feathers" (several articles, many coloured plates), Vol. B, pp. 156-186; "How To Attract and Study Birds", "Protecting and Conserving Our Birds", Vol. B, pp. 187-196.

*16 mm. Sound Films**Ontario Visual Education Branch*

The Loon's Necklace (colour) (A-19) (also available from Ontario Department of Lands and Forests)

Birds in Winter (SN-13)

Birds of Prey (SN-14)

Building Bird Houses (colour) (SN-107)

Attracting Birds in Winter (colour) (SN-108)

Birds That Eat Insects (colour) (SN-110)

Birds That Eat Seeds (colour) (SN-111)

*Film Strip**National Film Board of Canada*

Common Birds of Canada

7

THE WEB OF LIFE

HAVE YOU EVER carefully observed, for several minutes at one time, what happens in a spider's web? Whether you have or not, fig. 7-1 and the description accompanying it will

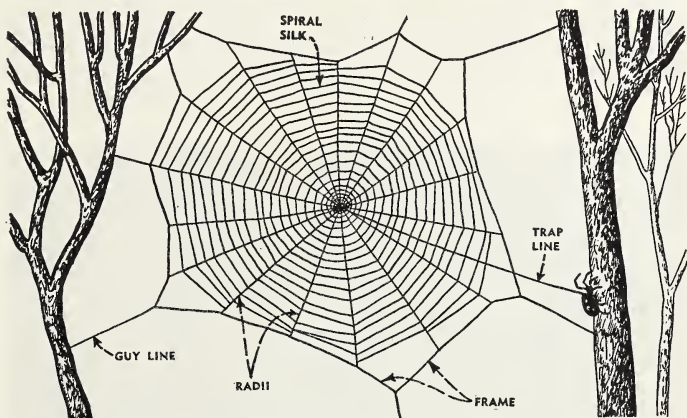


FIG. 7-1. AN ORB WEB OF A GARDEN SPIDER.

Find these: the framework that surrounds and supports the web, and the guy-lines that hold the frame in place; the centre or hub of the web and the radii or spokes extending out from it to the frame; the spiral silk thread extending round and round the web from the centre outwards and attached every time it crosses a radius; the trap line attached to the hub of the web and extending to the spider hiding at the edge of the web.

The spiral silk is elastic and sticky, easily entangling any insect that comes into contact with it. The vibration of a disturbed web is transmitted to the waiting spider through the trap line. Then the spider attacks its prey.

help you to understand how wonderful is the web of a common orb-weaver spider, such as the black and yellow garden spider. The builder of the web rests in its centre or lies in wait in some secluded place close to the web, with its feet resting on the trap line from the web. If a fly or some other insect alights on any part of the web, the whole structure vibrates, for every thread is connected with every other thread. Whether the spider is at the centre of the web or waiting at the end of the trap line, it feels the slightest jar and rushes over the web to deal with the entangled victim. On page 133 we shall explain how the spider's web illustrates the idea of the web of life.

Plants and Animals Live Together

Let us think of a rural community whose residents live in a small town or village and on the surrounding farms. The farmers grow the crops and raise the livestock that provide food for all the people in the community. Storekeepers in the village buy and sell both farm products and manufactured goods and thus



FIG. 7-2. A PLANT AND ANIMAL COMMUNITY IN A WOOD.

Find these: the owl in the tree above the rabbits; the squirrel collecting mushrooms; the raccoon feeding on a fish by the water; the birds feeding on berries in the trees at the left; and the bird building a nest.

try to satisfy the needs of everyone. Teachers, doctors, clergymen, lawyers, engineers, and many others in the community work in the interests of any who need their services. All the people in the community thus depend upon one another.

A wood, whether large or small, is a community of plants and animals living together and depending upon each other (fig. 7-2). Among the plants are trees and shrubs, small flowering plants and ferns, mosses and mushrooms; among the animals may be owls and songbirds, raccoons and rabbits, frogs and insects. Living trees provide shade, nesting places, and food for the animals; dead trees and their decaying remains nourish the mushrooms and add nutriment to the soil. Rabbits feed upon the vegetation, but may well become meat for the owls. Song birds rid the trees of injurious insects in return for nesting sites and protection. Raccoons live in hollow trees and feed upon frogs and insects. Frogs, too, prey upon the insects. Thus we see that the plants and animals of this wood community are largely dependent one upon another.

All three of the examples mentioned above—the spider's web, the rural community of people, and the community of plants and animals living together in the woods—illustrate what has been called the web of life. In the spider's web, every silken thread is affected when an insect alights on any thread of the web. In the rural community, each individual, directly or indirectly, contributes to the welfare of, and receives some benefits from, many other people. In a community of plants and animals in the wood, the various living things are so closely interrelated that the removal of one kind of plant or animal may change the ways of living of several others. All nature makes up a very complicated web of life, with living things depending in many ways upon each other as well as upon the soil, the water, and the air around them.

Charles Darwin, a great scientist, has shown how cats, mice, bumblebees, and red clover are woven together to form one pattern in the web of life. Cats eat field mice; field mice destroy

bumblebees' nests; and bumblebees pollinate red clover. Therefore, the more cats, the fewer mice; the fewer mice, the more bumblebees; the more bumblebees, the more red clover seed.



FIG. 7-3. ANIMALS DEPEND UPON GREEN PLANTS.

The screech owl (a meat-eating animal) feeds upon mice (plant-eating animals); mice feed upon wheat and other plant foods.

Animals Depend upon Green Plants. If there were no green plants on the earth, there could be no animals. All animals depend upon green plants for their food and, in part, for the oxygen they breathe; and many animals seek the shelter and protection of plants.

Only green plants can use water and minerals from the soil, and carbon dioxide from the air, to make living matter. All animals, and all plants that lack chlorophyll, must have ready-made food, either vegetable or flesh. Therefore, none of them can live without green plants.

We have already learned that animals may be divided into three groups, namely, plant eaters, flesh eaters, and animals with a mixed diet. Plant-eating animals (herbivores), such as cows, sheep, rabbits, deer, elephants, squirrels, and

many birds and insects, obtain their food directly from plants. Most of these animals eat roots, leaves, stems, fruits, seeds, or buds. Squirrels often eat mushrooms, but these plants obtain their nourishment from the decayed remains of green plants. Meat-eating animals (carnivores), including minks, coyotes, hawks, owls, kingfishers, bats, bass, tigers, and wolves, eat animals that eat plants. The mice eaten by hawks and owls eat grain (fig. 7-3), and the fish eaten by kingfishers feed upon plant life. Black bass eat smaller fish and water insects; these eat still smaller water animals; but the smallest water animals obtain their food from minute water plants. Therefore, these carnivorous animals depend indirectly upon green plants for their food. Such animals as bears, cats, dogs, pigs, poultry, robins, and quail eat both plant and animal foods and, therefore, depend upon green plants for food both directly and indirectly.

Many animals depend upon plants for shelter, homes, and protection. Raccoons and woodpeckers make their nests in the trunks of trees, and beavers use trees to make their dams and homes. Birds build their nests in trees, shrubs, and grass, and among swamp plants. Wasps use wood to make their paper nests, and man employs wood in constructing many parts of his home.

Plants provide temporary refuge for many animals attempting to escape from their enemies or seeking protection from unfavourable weather conditions. Squirrels and cats climb trees to escape pursuers. Mice seek shelter in tunnels among grass roots. Fish obtain shade from trees and fallen logs, and they avoid detection by their enemies by hiding under plant debris. Insects escape notice by hiding under leaves and bark, and foxes and deer rush for the cover of dense forests when man appears.

Some Plants Depend upon Animals. To produce new plants under favourable conditions for growth, flowering plants must produce seeds, and these seeds must be scattered away from the parent plants. Seed production depends upon pollination, the transfer of pollen from stamens to stigmas. Bees pollinate many

kinds of plants, including fruit trees, garden flowers, and clovers. Hummingbirds and some butterflies also carry pollen. When pollination has been accomplished and fruits and seeds produced, other animals carry the seeds far enough from the parent plants that the seedlings will have sufficient space, light, food, and moisture to grow well. Birds eat fleshy fruits and discard their seeds, and mammals carry seeds that stick to their hair or fur. Squirrels bury acorns and other nuts for winter food, forget them, and leave the seeds to germinate and produce seedling trees.

Animals help plants in other ways. Earthworms and some other ground animals dig burrows that permit air and water to pass easily through the soil to the roots of plants. Birds, bats, and skunks protect trees and other plants by devouring insects that attack them. The bodies of some insects become the food of pitcher plants and sundews, both of which have special devices to trap and hold any insects that touch them.

Animals Depend upon Each Other. Meat-eating animals could not live without the other animals that become their food. We call such meat-eating animals *predators*. Hawks, owls, weasels, and minks are predators when they eat mice; wolves are predators when they eat deer; foxes are predators when they take grouse; and cats, when they catch birds. Man, too, is a predator, and a very successful one. He catches fish, traps and shoots wildlife, and slaughters farm livestock. His implements of hunting are more efficient than those of any other predator. We do not condemn man for catching fish and killing other animals for his food; neither should we condemn wild predators when they take animals for food. It is a part of the web of life, of Nature's scheme, that some animals should feed upon others.

Predators are often desirable. We understand how well hawks and owls serve us when they eat field mice, for without this check on their multiplication, the mice would destroy huge quantities of grain and grass. The killing of deer by wolves can be desirable, also. When there are enough wolves to kill many deer, it is evident that deer have become too plentiful and that there is no

need for man to protect them. An over-population of deer would lead to the destruction of the undergrowth in our forests, to scarcity of food for the deer themselves, and, perhaps, to the spread of contagious diseases that attack deer. Predators are useful to the race of animals they feed upon, for they usually catch the weakest and least desirable of any species, leaving the strongest and best adapted individuals to multiply.

Animals help each other in many other ways. After ground-hogs dig their burrows, they may move away and leave their homes for rabbits and snakes to occupy. Old woodpecker holes in trees are taken over by bluebirds and screech owls. Cowbirds help cattle by destroying insect pests on them and around them. Beavers warn their fellows of danger by slapping the tail on the water, and the excited chatter of blue jays warns rabbits, squirrels, and quail that danger, perhaps in the form of a fox, is near.

Animals such as bees and ants are called *social animals* because they live in colonies, sometimes thousands together, for the good of all (figs. 1-3 and 5-8). All members of the colony benefit from the sharing of the work of the colony among workers, queens, and other classes of individuals. Other examples of animals helping each other are: wolves hunting in packs, fish travelling in schools, and beavers working together to build dams and homes.

Man Depends upon Both Plants and Animals. In *General Science*, Book 1, we learned of many ways in which man uses plants to obtain food, to make his clothing and shelter, to beautify his surroundings, and to make his life more enjoyable. All of man's food, whether vegetable or animal, comes directly or indirectly from green plants. Paper and cloth, nylon and rubber, wood and many other building materials, fur and leather come from plants or from animals that depend upon plants. Our ornamental trees and shrubs and other flowering plants give us shade and beautify our surroundings. Plants help us by conserving water supplies and by preventing soil erosion. Bacteria and mould plants are valuable in the making of butter and cheese. When plants decay, they enrich the soil.

Throughout the ages man has been served in various ways by wild animals. Fish, game birds, and game mammals have provided food and sport. Some insects have helped to provide clothing and food (chapter 5). Animals of many types have helped man to control injurious insects and vermin.

Early man depended entirely upon wild plants and animals, for he had not learned to domesticate them so that they might serve him better. As time passed, man trained dogs to hunt other animals for his food and clothing. He domesticated goats and cows for milk. He tamed wild horses and oxen and used them to carry burdens, haul loads, and pull ploughs. By domesticating plants and animals, and improving them, man provided for himself a dependable supply of food of better quality and of wider variety.

Man Helps Plants and Animals. When man grows crops and raises domestic animals, he helps the plants and animals as well as himself. Garden flowers, vegetables, fruits, and farm crops thrive because man cultivates and fertilizes the soil, provides water for irrigation, and controls weeds. Man also provides domestic animals with shelter, food, water, and protection from predators, insects, and disease.

Plants and Animals Live Together in a Balanced Aquarium. A well-kept aquarium contains fish, snails, and perhaps other water animals living together with water plants. If the aquarium is kept in good light, but not in direct sunlight, the animals and plants will thrive for weeks or months without being fed or having the water changed. The animals must both eat and breathe. They will eat plants if other food is not provided. For breathing, they use oxygen dissolved in the water. This oxygen is given to the water by the green water plants as a waste product when they make food. The plants must obtain carbon dioxide to be used as raw food. This they take from the water. The carbon dioxide was dissolved in the water when it was breathed out by the fish and other animals. Thus, we see that the animals in an aquarium provide the green water plants with food, and these plants provide the animals with food and oxygen. When the

aquarium contains the right amount of plant life to satisfy the needs of the fish, and the right amount of animal life to satisfy the needs of the plants, we say the aquarium is *balanced*. As a review of this paragraph, study fig. 7-4.

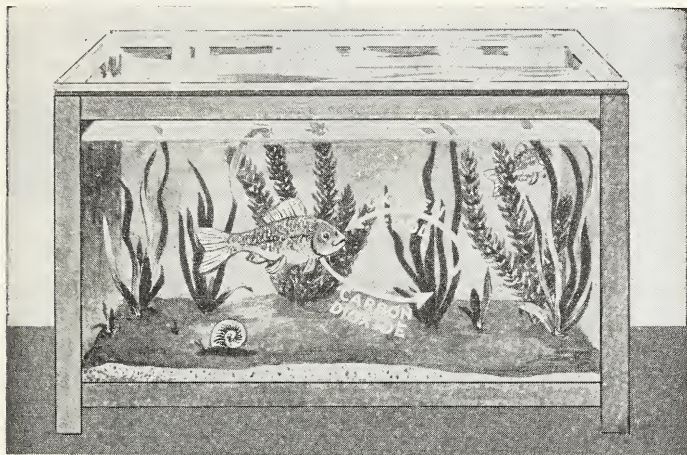


FIG. 7-4. A BALANCED AQUARIUM.

The Balance in Nature. When white men first came to make their homes in Canada, they found the forests and streams, the plants and animals, much as they had been for ages. For the Indians, there were plenty of wild turkeys, trout, and deer; for foxes, wolves, and other flesh-eating animals, there were plenty of deer, rabbits, and mice; for these plant-eating animals, there was sufficient vegetation. Trees grew on land best suited for trees; grass grew where conditions were most favourable for grass; streams flowed clear and full; and there was little erosion. Nature had been left to herself, disturbed but little by the Indians, and had kept the soil, the water, the plants, and the animals in balance with each other, much as we may keep them in balance in a balanced aquarium. Now study fig. 7-5.

When any locality is left to itself, undisturbed by man or any unnatural conditions, the same kinds of plants and animals, and

in about the same numbers, will live there from year to year over long periods of time. We say that there is a balance among all the plants and animals living there, and we call this balance

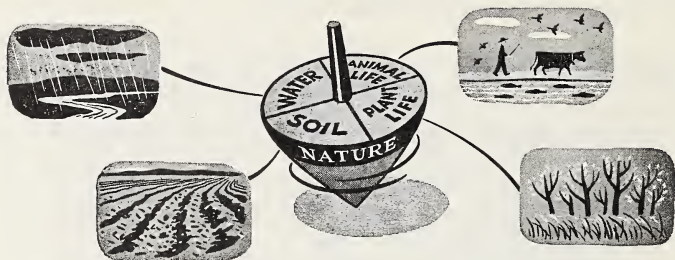


FIG. 7-5. NATURE'S BALANCE.

the balance in nature. So life goes on in a wildlife community year after year. Some plants and animals may multiply more rapidly if their food is plentiful; others may, for a while, become scarce. But little permanent change in the balance in nature



FIG. 7-6. A BALANCE IN NATURE.

This drawing shows a balance among the plants and the plant-eating animals at the left, and the meat-eating foxes. When the vegetation grows well, the rabbits, squirrels, and mice have plenty of food and increase in numbers. Then the foxes have more food and will also increase in numbers. The increased number of foxes will soon reduce the number of squirrels, mice, and rabbits to the former level. A balance in which there is a fairly constant population of foxes, mice, squirrels, and rabbits, favourable to all, continues most of the time.

is likely to happen unless man or some other outside factor interferes. Study fig. 7-6.

Frequently, man changes the balance in nature. Because one or two hawks or owls steal a chicken, a farmer may decide to do away with all the hawks and owls he can find. As he shoots them off, mice and rabbits get a chance to live unmolested and multiply rapidly. In the absence of their natural enemies, these rodents may then rob the farmer of crops worth more than the fowl eaten by the hawks and owls.

Weather conditions also upset or change the balance in nature. A dry season reduces the growth of plants. This makes it harder for mice to find food, and some die. If there are not enough mice to feed the hawks and owls, these birds will either seek other food, perhaps other useful birds, or go elsewhere. When favourable weather conditions cause plants to grow well again, the mice thrive and multiply. Hawks and owls return again or begin to eat mice in preference to birds. Songbirds, as well as hawks, again become more plentiful.

Food Chains. Though hawks do not eat foliage, they depend upon green leaves for food. Most hawks eat some smaller birds. Many of these birds feed upon spiders. Spiders often eat plant lice as they suck the sap from the leaves and flowers of garden plants and fruit trees. The plant food in this sap was made with the help of the chlorophyll in the green leaves. Naturalists call such a series of living things, linked to each other by food habits, a *food chain*. The food chain just spoken of has five links—hawks, smaller birds, spiders, plant lice, and plant sap.

Many food chains in nature are well known to us. When owls eat mice and mice eat wheat, we have a three-link food chain consisting of owls, mice, and wheat. When a lynx eats a fox that ate some rabbits that ate grass, we have a four-link food chain. Here are a few more food chains: wolf, deer, seedling trees; man, cattle, clover; cooper's hawk, robin, cherry; sharp-shinned hawk, bluebird, cutworm, cabbage; hawk, snake, frog, grasshopper, grass.

Food Chains: from Green Plants to Man

Green Plants	Links in the Chain	Man's Food
Minute Water Plants	Minute water animals, eaten by small fish, eaten by large fish	Fish
Land Plants Farm crops Flowers Cereal crops Seeds	Cows, sheep, pigs, poultry Bees gathering nectar Flour and meal Poultry	Meat, butter, cheese Honey Bread and pastry Eggs and meat



FIG. 7-7. ONE OF NATURE'S FOOD CHAINS.

A sharp-shinned hawk eats bluebirds; bluebirds eat cutworms; cutworms cut off cabbage plants at the ground level and feed on their foliage.

How Man Changes the Balance in Nature

How Man Upsets Nature's Balance. Man's activities have upset the balance in nature. To establish homesites and to grow crops, man cut the forests. This deprived many kinds of wildlife of homes, food, and protection. By driving away beavers, he caused floods, for these would have been prevented by beaver dams. Man drained swamps and thus destroyed the natural haunts of muskrats, minks, and many birds. These perished or

went elsewhere. Man ploughed under prairie grasses, leaving no place for the buffalo to roam and feed. To construct railways and highways, he built dams across rivers. In British Columbia this prevented the salmon from going upstream to lay their eggs.

Man has upset the balance of nature by building cities and establishing industries. Not only did these activities remove the natural vegetation and drive away the animals that lived on these sites, but they have led to the pollution of streams by sewage and factory wastes, making the water unfit for fish.

Man has introduced many kinds of plants and animals into new localities, some purposely, others accidentally. Some of these plants and animals have become destructive pests, such as the European corn borer and the gypsy moth, both of which entered accidentally in imported produce. These have become pests because man failed to bring with them the natural enemies that had kept them under control where they lived previously. The rabbit was taken to Australia as a pet, but it increased in numbers until it became very destructive to crops. Deer taken to New Zealand without such enemies as wolves increased so rapidly that they destroyed seedling trees and forests to such an extent that erosion resulted on a large scale.



FIG. 7-8. MAN UPSETS THE BALANCE IN NATURE.

Compare this drawing with that in fig. 7-6. By trapping foxes, man reduces the enemies of squirrels, rabbits, and mice. This permits them to increase and devour more plant life.

How Man Tries To Restore the Balance in Nature. Our studies of conservation have shown us many ways in which man has tried and is trying to restore the balance in nature that he upset in the past. By planting forests, man has brought back some of the wildlife and restored streams and fishing in some places. By regulating hunting, fishing, and trapping, he has given wild animals an opportunity to increase in numbers to a reasonable extent. By setting apart national parks, man has protected the remaining buffaloes, elk, and antelopes, and has enabled them to increase in numbers. By protecting songbirds, hawks, and owls, he has increased their efficiency in controlling harmful insects and mice.

Scientific investigations have helped in many ways to restore the original balance of nature or to establish a new and favourable balance. Here is one example. A certain kind of scale insect, brought accidentally into California, increased so rapidly that whole orchards of lemon and orange trees were threatened with destruction. Indeed, thousands of fruit trees did die. Then scientists introduced from Australia a particular kind of ladybird beetle that feeds upon this scale insect. This beetle multiplied rapidly and soon brought the scale insect under control.

Things To Do

1. Explain this quotation:

When farmers dried
Great sloughs to raise more corn,
Wild birds died,
And clouds of dust were born.

Oscar Ostlund

2. Livestock on our farms is very important to the farmer as a source of income and to all of us as a source of food and clothing. List all the ways you can think of in which (a) livestock on a farm depends upon green plants, (b) livestock depends upon people.

Review Exercises

1. How does the following quotation illustrate the interdependence of plants and animals and the balance in nature:

“On a milkweed plant growing in a pasture field we observed tiny aphids sucking juice from the leaves, ladybird beetles feeding upon the aphids, ants crawling among the aphids and protecting them in order to obtain their honeydew, the eggs of monarch butterflies under the leaves, larvae of monarch butterflies feeding upon the leaves, and long, reddish milkweed beetles eating foliage (the only food they will take).”

2. Give three examples of each of the following:

- (a) animals depending upon green plants;
- (b) animals depending upon each other;
- (c) man depending upon other animals;
- (d) man helping other animals;
- (e) food chains.

3. State five ways in which the balance in nature has been upset by man.

4. Try to discover one way in which people in your community are trying to restore the balance in nature or to establish a new balance.

5. Consider in what respect it is true that you (a) are eating grass when you drink milk, (b) are being nourished by wheat when you eat eggs, (c) are dependent upon green plants when you eat pork.

Your Word List

Interrelated, dependent, herbivores, carnivores, carnivorous, pollination, predator, meat-eating animal, injurious, domesticated, balanced aquarium.

Read

Compton's Pictured Encyclopedia, 1953 Edition: “How Plants and Animals Depend on One Another”, Vol. NO, pp. 52-54.

*16 mm. Sound Films**Ontario Visual Education Branch*

Life in a Pond (food chains, etc.) (colour) (SB-13)

Interdependence of Pond Life (SB-8)

This Vital Earth (colour) (SG-46)

Deer Live in Danger (struggle for survival) (colour) (SN-112)

National Film Board of Canada

Your Forest Heritage (colour)

Tomorrow's Timber (colour)

Look to the Forest

Land in Trust

Soil for Tomorrow (colour)

Zoo

Ontario Department of Lands and Forests

Realm of the Wild (food chains, etc.) (colour)

UNIT THREE

Air in Man's Service

8. *THE AIR AROUND US*

Air is a real substance, essential to all life. Because air has weight, the atmosphere presses on everything it touches. Fortunately, we can measure the pressure of the atmosphere and make it serve us in many ways. We can also compress air for use in footballs and tires.

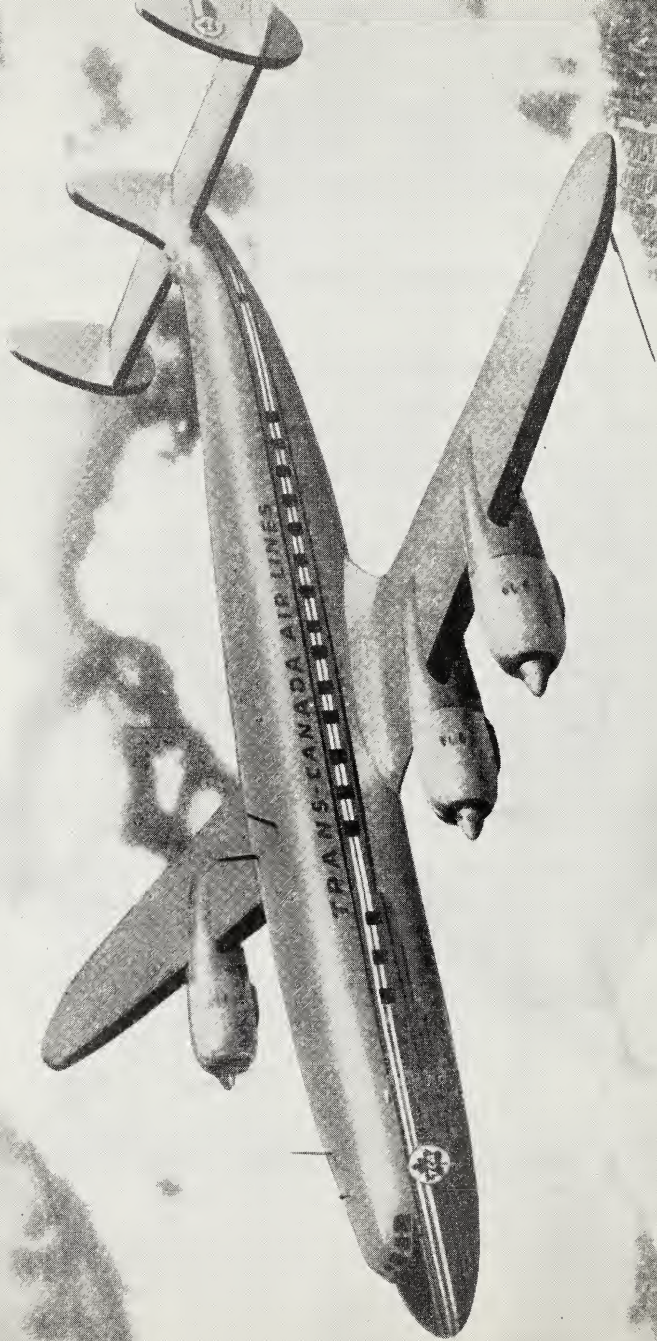
9. *AIR IS A MIXTURE OF GASES*

Air is composed of oxygen, nitrogen, carbon dioxide, some water vapour, and a trace of some other gases. The oxygen in air makes burning possible and causes rusting. When air is heated, it expands; when cooled or compressed, it fills less space; when mixed with water, some of it dissolves.

10. *AIR AND HEALTHFUL BREATHING*

Every living thing uses air to breathe. During breathing, some of the oxygen in the air is used up, and some carbon dioxide and water vapour are formed as waste products. Modern air-conditioning systems make air healthful for breathing by keeping it clean, comfortably warm, sufficiently moist, and in constant circulation.

The accompanying illustration shows one of the Super Constellation aeroplanes used by TCA. The fourth engine is hidden by the body of the plane.



8

THE AIR AROUND US

WE LIVE IN AN INVISIBLE OCEAN OF AIR. And what an ocean it is! It extends over the whole surface of the earth from pole to pole and for many miles above us. Wherever we go, whether we are down in a mine or up in an aeroplane, we find ourselves completely surrounded by the earth's all-enveloping ocean of air.

"We never miss the water until the well goes dry" is a common saying. Fortunately, we never have an opportunity to miss the air, for we could not live without it. True, we never see air, for it is invisible. But we can feel it when it rushes by us as wind, or when it is driven at us by a fan. We can even hear air, or the effects of air, as the wind whistles through the trees in a storm, or a breeze rustles the leaves.

Some Characteristics of Air

Air Is a Real Substance. Is air something real? Some experiments will answer this question for us.

EXPERIMENT 8-1. *Does air occupy space?*

Open a paper bag wide. Pull the edges of the open end of the bag closely together, sealing the opening. Now, try to flatten the bag (fig. 8-1,A). Why is it impossible to flatten the bag without letting air escape?

EXPERIMENT 8-2. *Another way of finding out whether air occupies space.*

Lower a tumbler, mouth downwards, into water (fig. 8-1,B). Does water enter the tumbler? Why not? Tip the tumbler a little to one side so that some bubbles of air escape. Why does water now rise a little way in the tumbler? Let more air out. How does the water level in the tumbler change after each bubble of air escapes? Why?

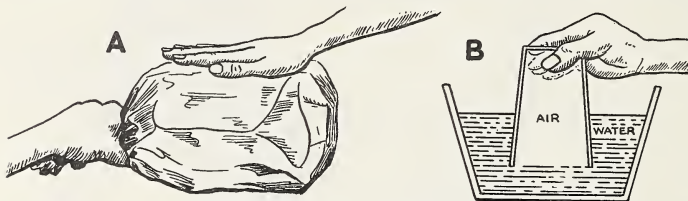


FIG. 8-1. AIR OCCUPIES SPACE.

A. Air in the bag keeps it from being flattened. B. Air in the tumbler prevents water from entering it.

Where We Find Air. We know there is air in the atmosphere around us and above us. Let us find out whether it is in the soil and in water.

EXPERIMENT 8-3. *Is there air in soil?*

Fill a tumbler or a large glass vessel three-quarters full with garden

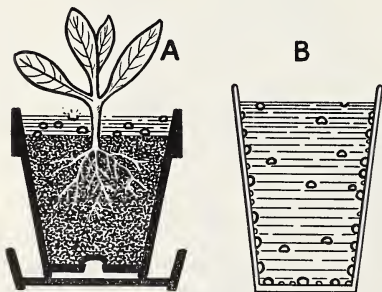


FIG. 8-2. SOIL AND WATER CONTAIN AIR.

A. The bubbles seen in the water contain air driven from between the soil particles by the water penetrating the soil. B. The bubbles on the glass and those rising through the water contain air that had been dissolved in the water.

soil. Add water, covering the soil to a depth of about an inch. Observe the water closely, noting the breaking of any bubbles on its surface. What do the bubbles contain? Where did they come from? Does garden soil contain air? Modify the experiment by pouring water over dry soil in which a potted plant is growing (fig. 8-2,A). Answer the questions asked above.

EXPERIMENT 8-4. *Does water contain air?*

Fill a tumbler with cold water. Leave the tumbler in a warm place for an hour or so (fig. 8-2,B). Look for bubbles on the inside of the glass. What do they appear to contain?

Heat the water slowly. What happens to the bubbles? What seems to be in the bubbles seen rising in the water? Which can contain more air, cold water or warm water?

Both soil and water contain air. Air fills the spaces between soil particles and dissolves in water much as sugar does. The looser the soil, the more space there is for air. The colder the water, the more air it can contain.

Air Is Essential for All Life. The air above the earth's surface, in the soil covering it, and in bodies of water is essential to life. No living thing, either plant or animal, can exist without air to breathe. Birds, insects, man, and many other forms of animal life breathe the free air of the atmosphere surrounding the earth. Every part of every living plant—its leaves, its flowers, its green stems, even its bark—breathes in the oxygen of the air and breathes out carbon dioxide, somewhat as we do.

Earthworms, ground insects, and other animals that live underground depend upon the air in the soil. Even the roots of plants and the bacteria in soil need air for breathing.

In water, too, both plants and animals must have air to breathe. Fish and other water animals use gills or some other special organs to take the air they need for breathing from that dissolved in water. Streams containing cold water, or flowing over falls or through rapids, provide the most dissolved air and, therefore, serve most water animals best. If fish or other water animals are to live healthily in an aquarium, either the water in it must be changed frequently, or the aquarium must contain living green plants, which give oxygen to the water.

We learned, in *General Science*, Book I, how the carbon dioxide and the nitrogen in air are useful to living things. Green plants use carbon dioxide as raw food. The roots of legume plants bear little nodules containing bacteria that take nitrogen

from the air in the soil. These bacteria then change the nitrogen into raw food which is absorbed by the roots.

Air is essential to all life in another way. It forms a protective cover over the whole earth. As a thick insulator, it prevents some of the sun's rays from reaching the earth. Thus, during the day, air helps to keep the earth's temperature from rising higher than life can withstand, and, after sunset, it slows down the escape of heat stored up in the earth throughout the day. Without the atmosphere, the earth's temperature would probably fall far below zero every night. If this were to happen, all life would soon disappear.

How fortunate for man that nature has arranged to place air, containing life-giving oxygen, in the atmosphere, in the soil, and in the waters of the earth.



FIG. 8-3. ALL LIVING THINGS REQUIRE AIR.

Find the ten arrows (two in G and H) indicating air being taken in by the plants and animals shown. A, a frog breathing in air through its nostrils; B, a water beetle collecting air under its wings for breathing; C, a mosquito wriggler extending a breathing tube to the surface of the water; D, man breathing through the nostrils to the lungs; E, the gills of a fish, capable of taking oxygen from air dissolved in water; F, the tiny pores through which the grasshopper breathes; G, a green plant breathing through both its leaves and its roots, also taking in carbon dioxide as raw food through its leaves; H, germinating seeds using oxygen for breathing.

Does Air Have Weight? The blanket of air surrounding the earth extends upwards at least two hundred miles. Now that we know that air is a real substance, that it is a form of matter, we would expect it to have weight. Let us find out by experiment whether it has.

EXPERIMENT 8-5. *Weigh some air.*

Attach an inflated football (or bicycle tube or balloon) to one end of a yardstick and a paper bag to the other end. Suspend the ruler by means of a string or wire. Put sand into the paper bag until the yardstick is horizontal. Deflate the ball or tube. In which direction does the paper bag move? Why? See fig. 8-4.

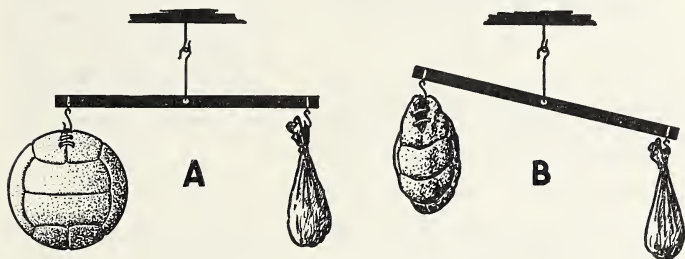


FIG. 8-4. AIR HAS WEIGHT.

A. The weight of the football and the air in it is balanced by the weight of the paper bag and the sand in it. B. How does the change in the position of the objects show that the ball weighed less when air was let out of it?

Yes, air has weight. The air in an ordinary classroom weighs about half a ton.

Does the Air of Our Atmosphere Exert Pressure? All objects that we can think of have weight: they are drawn towards the earth by gravity, and press down on whatever may lie beneath them. Air has weight, even if not very much in comparison with most substances. Because air is piled so very high above the earth, the total weight of the air above the earth is very great.

EXPERIMENT 8-6. *Does the atmosphere exert pressure?*

Fill a tumbler with water. Completely cover its mouth with a piece of paper. While holding the paper firmly, invert the tumbler. Take

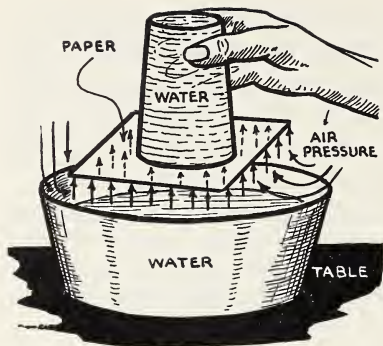


FIG. 8-5. THE ATMOSPHERE EXERTS PRESSURE.

Explain why the paper is not pushed off the glass by the weight of the water above it. In what direction is the air pressing on the paper?

your hand from the paper. Why doesn't the water push the paper off? See fig. 8-5. Hold the paper with your hand as you tip one edge slightly from the glass to let out a little water. Press the paper to the glass and remove your hand again. After more experimenting and some discussion, you will conclude that only air pressure beneath the paper holds up the water, the enclosed air, and the paper. This air pressure is caused by the weight of the atmosphere pressing downwards around the tumbler and upwards beneath the paper.

EXPERIMENT 8-7. *Why do suction cups stick to windows?*

Wet two pieces of glass and place them face to face. Why is it difficult to pull them apart?

Air presses against the outside of each piece of glass at the rate of 15 pounds per square inch. It cannot push against the inside surfaces because the water keeps air out. Similarly, by pushing against the outer surface of the suction cup fitted in an air-tight manner against glass or any other smooth surface, air holds the cup in place.

EXPERIMENT 8-8. *How great is the pressure of the atmosphere?*

Place a little water in a rectangular container, such as a large varnish can. Boil the water in the open can until steam replaces the air in the can. While steam is escaping, remove the can from the heat and close it immediately, making it air-tight. Pour cold water over the can. Why does the can collapse? See fig. 8-6.

Imagine a pile of feathers as high as Mount Everest, five and a half miles high. The feathers at the bottom, pressed down by all those on top, would form a dense mass. True, air is lighter than feathers, but it is heaped on the earth's surface to

a height more than 25 times that of Mount Everest. Compressed by such a high pile of air above it, the air at the earth's surface is naturally much denser than the air some distance above the earth's surface. For the same reason, air at the earth's surface exerts greater pressure than air some distance from the earth's surface. At all heights in the atmosphere this pressure is exerted in every direction. No wonder the air collapsed the can.

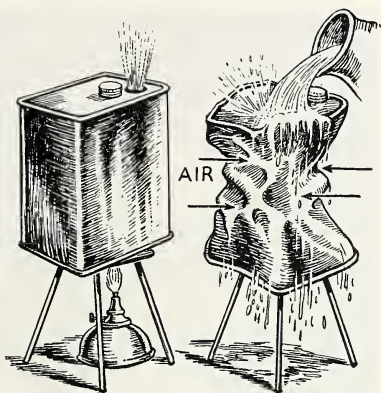


FIG. 8-6. AIR PRESSURE CAN COLLAPSE A CAN.

A. What did the can contain after the water was boiled for a while? B. How did the cold water make it possible for the pressure of the air to collapse the can?

EXPERIMENT 8-9. *Can you drink "pop" through a straw without the help of air pressure?*

(a) Drink through a straw from an open bottle. Why does the liquid rise through the straw?

(b) Obtain a one-holed stopper to fit a bottle similar to the one used in (a). Through the hole, insert a straw or a glass tube that fits it tightly. Seal around it with vaseline. Fill the bottle with liquid and push the cork into place firmly. Now try to drink through the straw or the glass tube. Can you? Loosen the stopper and try again.

When we "draw in", we really reduce the air pressure on the surface of the liquid in the straw. This makes the air pressure on the surface of the liquid inside the straw less than the air pressure on the surface of the liquid outside the straw. The outside pressure then forces the liquid up through the straw into the mouth. This is repeated each time we "draw in". When we tried to drink through the straw fitted tightly in the stopper, air could not get into the bottle to force the liquid up.



FIG. 8-7. AIR PRESSURE CAN FORCE LIQUID UP THROUGH A STRAW.

A. What forced up the liquid when the girl sucked on the straw? B. Why was the boy not able to suck liquid through the straw fitted tightly in the stopper of the bottle?

PROBLEM.

Why is it easier to pour liquids from a sealed can with two holes than from a similar can with one hole?

The pressure of the air downwards on the earth is about 15 pounds on each square inch. Therefore, the pressure exerted by the air on one cover of this book is about as much as a 600-pound weight. How, then, can we lift the book? To answer this, remember that the atmosphere pushes upwards on the underside of the book with an equal pressure. Therefore, we need lift only the weight of the book. Fortunately for us, there are pressures exerted from the inside of our bodies equal to the air pressure on the outside. If this were not so, our bodies would be collapsed by the weight of air equal to that of three elephants.

Atmospheric Pressure

How Can We Use the Pressure of the Atmosphere? The pressure of the atmosphere helps us in many ways. We have already seen how it enables us to suck liquid through a straw. Similarly, air pressure makes it possible for us to pump water, use a

medicine dropper, fill a fountain pen, clean our rooms with a vacuum cleaner, and travel by aeroplane.

Fig. 8-8, A shows how a medicine dropper works. Hand pressure on the rubber bulb forces some air from the tube. When the pressure on the bulb is released, the pressure inside the tube becomes so little that the outside air pressure forces liquid into the tube and holds it there until we force it out again by pressing the bulb. To fill a fountain pen, we first press a lever to force air from the ink sac, then we release the lever to let the outside air pressure force ink into the pen.

Pumping water is somewhat like sucking liquid through a straw. A simple experiment will show how a pump works.

EXPERIMENT 8-10. *Find out how it is possible to pump water.*

Cut or break the closed end from a test tube, or obtain an open tube about one-half inch across (fig. 8-8, B). Make a piston by wrapping soft string around a thick pencil

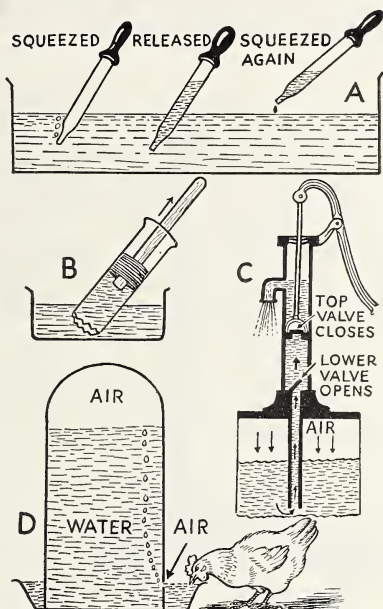


FIG. 8-8. HOW AIR PRESSURE WORKS.

A. Air helps us to use a medicine dropper. What happens when the bulb is squeezed? Why does water rise in the tube when the bulb is released? What holds the water in the dropper until the bulb is squeezed again? B. Air pressure forces water up into the tube as the piston is pulled upwards. C. What forces water into the pump? Why does the water flow above the piston when the piston is lowered? How is the water lifted to the spout? D. A poultry drinking fountain. Air pressing on the outside water holds up the inside water. When the chickens have taken enough water from the outside part of the fountain, air moves past the water to the interior and forces out a little more water.

until the piston just fits tightly into the tube. Pump water with this. Why does water rise in the tube when you pull the piston up?

The air pressure on the surface of the surrounding water is sufficient to push the water up to the top of a tube about 32 feet long.

A water pump is so constructed that it will bring the water above the level of the piston in the pump (fig. 8-8,C). When the piston is lowered, the water presses a valve open and flows up through a tube in the piston instead of passing out of the lower end again. When the water has been pushed up far enough, it flows out of a spout. More water comes up with each stroke of the pump handle and replaces the water that flowed out of the spout. Study the diagram and try to understand how these things take place.

The motor of a vacuum cleaner drives a fan which lowers the air pressure in the part of the cleaner next to the floor. Air surrounding the vacuum cleaner is immediately pushed into this zone of low pressure by the pressure of the air farther away. As we move the cleaner over the rug, air from beneath, within, and close to the rug forces dust and dirt from the rug into the cleaner and into the cloth bag. The air passes on through the bag, but the dust remains within.

How Can We Measure the Pressure of the Atmosphere?

Early scientists were disappointed to find that they could not raise water to a height of more than 32 feet by pumping. They did not know that the atmosphere weighed too little to push the water any higher. Many experiments were performed to try to discover just how much the air weighs and, therefore, how much pressure it can exert. Finally the barometer was invented and the problem solved.

EXPERIMENT 8-11. *Make a barometer and measure the pressure of the atmosphere.*

Obtain a glass tube about 3 feet in length and closed at one end. Rest the closed end on a table and fill the tube with mercury. Place your finger over the open end as you invert the tube into a vessel

of mercury deep enough to cover the end of the tube. Remove your finger. What does the mercury do? We are not surprised to see the mercury fall, but why did it stay up as far as it did? What is in the space above the mercury? To prove that there is nothing above the mercury, tip the tube sideways and see that the mercury can go to the top of it. Study fig. 8-9.

Measure the height of the mercury in the tube above the surface of the mercury in the dish. It will probably be about 30 inches. The pressure of the air on the surface of the mercury in the dish is great enough to hold up a vertical column of mercury about 30 inches in height. Therefore, we say that the atmospheric pressure at the time of the experiment was 30 inches (of mercury). Read and record the length of the column of mercury on each of several days. Is the column always the same length?

A more convenient type of barometer than the one we have been working with is known as the *aneroid barometer*. Because it does not contain any liquid, it can be carried easily from place to place. Using an aneroid barometer, find the air pressure in the cellar, upstairs, on a hill, and at other heights. From your readings, would you expect the air pressure on a mountain to be more or less than at sea level? See fig. 19-7.

The atmospheric pressure at or near sea level is usually about 30 inches. If the place where you live is a few hundred feet above sea level, the column of mercury in your barometer will be less than 30 inches high.

Aviators flying in high altitudes require oxygen tanks to give them enough oxygen to breathe. The air a few miles up is too thin and contains too little oxygen to supply man's requirements.

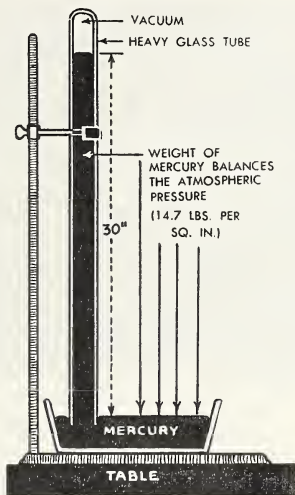


FIG. 8-9. MEASURING AIR PRESSURE WITH A BAROMETER.

What holds the mercury up in the tube? What height of mercury can the air hold up? How would any air in the top of the tube prevent the barometer from working?

We would expect this scarcity of oxygen because, at such heights, there is so much less air above to press down. We would also expect the air pressure to become less and less as altitude increases. For each 900 feet ascended above sea level



FIG. 8-10. AVRO C-102 JETLINER PASSENGER PLANE.

Built at Malton, Ontario, the first jet transport to be manufactured in North America.

the atmospheric pressure is reduced by about one inch. Knowing this, we may use an aneroid barometer to measure the pressure of the air at the top and the bottom of a building or a mountain, then calculate its height.

PROBLEM.

Near the earth's surface, the atmospheric pressure decreases about one-tenth of an inch for every 90 feet increase in altitude. What is the height of a mountain on which a barometer reads 27 inches when the pressure at sea level is 30 inches?

Other Conditions That Determine Atmospheric Pressure.

The air pressure at any place and at any time depends upon the temperature of the air and the amount of moisture in it, as well as upon altitude. When air is warmed, it expands. As a result, the air becomes lighter than it was. When the vertical column of air over a place becomes lighter, a barometer shows a lower air pressure.

Peculiar as it may seem, air becomes lighter, too, as it takes in more moisture. Thus a "falling barometer" (pressure becoming lower) often indicates moister air and foretells rain.

We Can Compress Air and Then Use It for Many Purposes

The air pressure about which we have been learning is caused by the weight of the air pressing down on the earth's surface and in all directions against everything it is in contact with. Now we are to learn about another kind of pressure by air. If you hold a finger over the end of the rubber tube of a bicycle pump, then press down on the pump handle, the air within can be pressed into a smaller volume. It becomes *compressed air*. If you let the handle go, it will be forced up again by the pressure of the compressed air in the pump. The more we compress air, the smaller the space it requires, and the more pressure it exerts against the walls of its container.

The air in an automobile tire is compressed air. When a tire is blown up to thirty-pounds pressure, the air in it presses against each square inch of the tube sufficiently to support a thirty-pound weight. The recently developed low-pressure tires have a larger surface than the older kinds and, therefore, do not need to have as much air pressure in them to carry the same load. Because the air in the tires has less pressure, the car rides more smoothly.

Compressed air has many uses. We put it in basketballs and footballs to make them bounce; we use it in automobile tires to absorb the shock caused by irregular road surfaces and to make riding more comfortable; it helps us to operate the brakes of railway cars and the doors of streetcars; it is used to blow sand against the surface of stone buildings to scour them clean, and also to remove paint from metal. In diving suits, compressed air makes it possible for divers to work in great depths of water.

PUPIL INVESTIGATION.

Find out why and how engineers who are carrying out building operations under water use caissons or diving bells, and how compressed air makes the operation of these devices possible.

Problems To Solve Experimentally

1. Place a cork on water in a large dish. Hold the hand tightly over the top of a lamp chimney; lower the other end of the chimney over the cork; push the chimney down into the water. What happens to the cork? Why did the water not enter the lamp chimney?

Continue to hold the lamp chimney in the same position, but remove the hand from over the chimney. Give two reasons why the water and the cork rush up through the lamp chimney.

2. Lower a tumbler into water. Fill it with water. Invert the tumbler, holding it mouth downwards. Lift the tumbler almost out of the water. Why does the water stay in the tumbler?

3. Fill a large dish with water. Lower a tumbler into the water and fill it with water. Turn the tumbler mouth downwards. Lower a second tumbler, this one empty, mouth downwards into the water beside the first tumbler, but a little lower. Pour the air from the second tumbler into the first tumbler. Explain what happens.

Find Out

1. How the crew and passengers in a plane obtain enough oxygen when flying at high altitudes.

2. What precautions the conquerors of Mount Everest took to protect themselves from the ill effects of cold temperatures, thin air, and lack of oxygen.

3. Why a straw sometimes flattens when you are drinking through it.

4. How a compressed-air drill works.

5. How air brakes work.

6. Which contains more dissolved air, water from a faucet or water that has been boiled.

Things To Do

1. Make a water barometer. See fig. 19-1.

2. Use an aneroid barometer to determine the height of a tall building or a high hill.

3. Find the weight of the air in some room in your home, knowing that 1 cubic foot of air weighs $1\frac{1}{4}$ ounces.

Test Your Knowledge

1. Tell how each of the following depends upon air, or something in air, and how it obtains its requirements: a green leaf, a fish, the roots of garden plants, earthworms, bacteria in milk or water.
2. Why would it not be possible to pump water from an air-tight well?
3. How could you prove at home that air is a real substance?
4. Draw a mercury barometer and label the drawing.
5. Explain why air is less dense at greater altitudes.

Your Word List

Atmosphere, barometer, altitude, sea level, mercury, oxygen, air pressure, compress.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Air—What It Is and What It Does", "Some Interesting Things To Do with Air", Vol. A, pp. 73-78; "Swift-winged Ships of the Sky", "How an Airplane Flies", "How Men First Learned To Fly", "Building and Flying Model Airplanes", Vol. A, pp. 85-110; "The Ocean of Atmosphere in Which We Live", Vol. A, pp. 453-455; "Man's First Aircraft—the Balloon", Vol. B, pp. 28-36.

9

AIR IS A MIXTURE OF GASES

AIR, LIKE WATER, was long considered a single substance. Now we know that both air and water are composed of more than one substance. A series of experiments will help us to find out what air is made of.

What Gases Make Up the Air?

More than a century ago, when many people still thought air was a simple substance, the Chinese believed that air contained one substance that made things burn and another substance that did not make things burn. Some experiments will show us whether they were right.

Air Contains Oxygen.

EXPERIMENT 9-1. *Is there something in air that makes things burn?*

Fasten a wire securely around a candle and twist the ends of the wire to form a handle. Light the candle. Now lower the lighted candle into a quart sealer. Cover the sealer with a piece of glass. Why does the candle's flame soon go out?

Remove the candle. Light it and lower it into the jar again. Replace the cover. Why does the candle not burn as long as it did the first time? Perhaps the candle used up something from the air in the jar while it burned the first time. See fig. 9-1,A.

EXPERIMENT 9-2. Does a burning candle remove anything from air?

Light a short candle. Use a few drops of the melted paraffin to attach the candle to a small piece of card. Float the candle and card on water in a plate or a cereal dish. Lower a sealer over them until the sealer's open top is under water. Observe any changes in

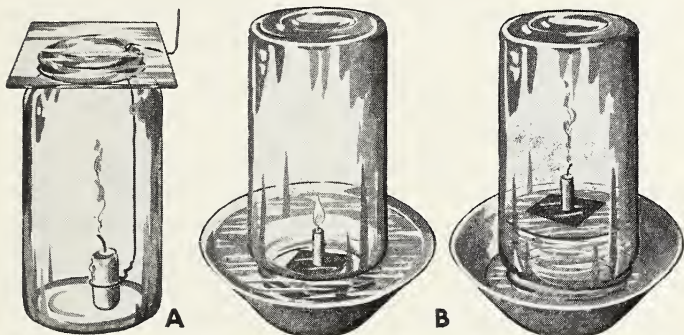


FIG. 9-1. BURNING CHANGES AIR.

- A. Burning stopped when the oxygen in the air was used up.
B. Oxygen makes up about one-fifth of the air.

the level of the water and of the floating candle in the jar. Why does the water rise in the sealer? What fraction of the sealer became filled with water? Now study fig. 9-1, B.

Repeat the experiment, using a candle that is not burning. Why doesn't the water rise now?

As the candle burned, it used up about one-fifth of the air in the sealer. The part of the air used up was oxygen. The candle could not continue to burn after the oxygen was used up.

The Chinese were right. Air does contain a substance that makes things burn. This is oxygen.

Oxygen is the part of the air we use in breathing. All living animals and plants breathe in oxygen. Fish obtain oxygen from the air in water. Aviators must take supplies of oxygen with them when flying at high altitudes. In hospitals it is supplied, in oxygen tents, to patients who have difficulty in breathing.

Nitrogen in Air. When the candle stopped burning in the sealer, four-fifths of the air was left unused. The candle could not continue to burn in this gas, so it went out. The gas left in the sealer was chiefly nitrogen. This is the part of air the Chinese believed would not make things burn.

When we breathe air, we breathe both oxygen and nitrogen. Although we breathe the nitrogen in, and out again, it does neither good nor harm to us. If, however, the air we breathe were pure oxygen, it would be harmful to us. As water dilutes medicine, so nitrogen dilutes the oxygen of air sufficiently that we may safely breathe it.

Nitrogen in the air helps us to produce better crops. As you know, the roots of clover, beans, and peas usually bear little knobs which contain a special kind of bacteria capable of taking nitrogen from the air in the loose soil and giving it to plants as food. Man has now discovered how to remove nitrogen from the air, and he uses it to make fertilizers.

Carbon Dioxide in Air. A third gas occurs in air in small quantities. It is called carbon dioxide. Let us learn about it by performing easy experiments.

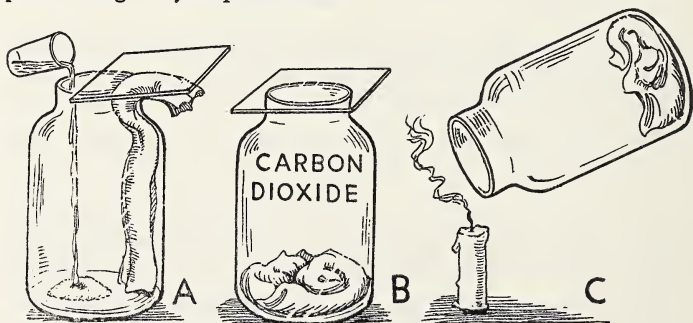


FIG. 9-2. MAKING AND TESTING CARBON DIOXIDE.

A. Vinegar and baking soda produced carbon dioxide. B. A jar of carbon dioxide. C. Carbon dioxide will pour and will put out a flame.

EXPERIMENT 9-3. *Make some carbon dioxide.*

Obtain a large sealer or glass jar, a quart or more in size, and with a close-fitting cover. Fold paper towels or other soft paper into three or four thicknesses and push them into and along the side of the

jar (fig. 9-2,A). (This will enable us later to invert the jar without pouring out the liquid.)

Put in two tablespoonsful of baking soda. Add half a glass of vinegar, a little at a time, keeping the jar covered as much as possible. Observe the foaming. The bubbles in the foam contain carbon dioxide.

Quickly pack the paper into the bottom of the jar to absorb or cover the liquid (fig. 9-2,B). Now we have a jar of carbon dioxide. Let us see what we can find out about this gas.

EXPERIMENT 9-4. *How does carbon dioxide affect a flame?*

Light a candle and set it upright in a saucer. Tip the jar of carbon dioxide over the candle as if you were pouring something from the jar (fig. 9-2,C). What happens to the flame? What caused the flame to go out?

This experiment shows that carbon dioxide will put out a flame. It does so by pushing away the oxygen. For this reason, the gas can be used to extinguish fires. The fact that you could pour carbon dioxide from the jar over the flame shows that the gas is heavier than air. Therefore, carbon dioxide tends to settle to the lower levels of any mass of air. This fact explains why a person is more likely to suffocate in the bottom of a well than near the top.

EXPERIMENT 9-5. *How we may test for carbon dioxide.*

Make some limewater by shaking a tablespoonful of builders' lime with water, then letting the lime settle until the liquid is clear. Pour off some of the clear liquid. This is limewater. Put a tablespoonful of this limewater into a tumbler. Make some more carbon dioxide as you did in experiment 9-3. Pour some of the carbon dioxide over the limewater in the tumbler. Cover the tumbler with your hand and shake it well. How does the limewater change in colour?

When limewater turns milky, we know there is carbon dioxide present.

EXPERIMENT 9-6. *Is there carbon dioxide in air?*

Use a bicycle pump to force air into a little limewater for several minutes. Does the limewater become milky? Does air contain carbon dioxide?

Carbon dioxide occurs in air in very small quantities—less than half of one per cent. It is put there by all living plants and

animals as they breathe. Fires, whether in factories, forests, or homes, add carbon dioxide to the atmosphere. The decay of both plant and animal materials also produces this gas.

Carbon dioxide in the air, even in such small quantities, is necessary for the existence of green plants. They must take it in through their leaves as a raw material from which to make plant food. If present in the air in too large proportions, carbon dioxide is harmful to people and other animals that breathe the air. To prevent harm in this way, we ventilate our homes and the buildings where we keep livestock.

Carbon dioxide has other uses. Produced by yeast and baking powder, it makes bread and cakes "rise". Dissolved in soft drinks, it gives them a pleasant "nip". In solid form, called dry ice, it is used to pack perishable foods and keep them cold.

Water Vapour in Air. Air always contains some water vapour. We can prove this either by showing that water enters the air or by taking water out of air.

EXPERIMENT 9-7. *Can you add water to the air?*

Leave saucers containing equal amounts of water in various places—sunny, shady, cool, warm, calm, and breezy. Where does the water go? Under what conditions does the water disappear fastest? Slowest? How does this experiment prove that air contains water?

EXPERIMENT 9-8. *Can you take water from air?*

17 Obtain a glass or a metal cup and be sure the outside of it is dry. Fill it with very cold water. Leave it in a warm room for several minutes. Now feel the outside of the vessel. Is it dry? Watch for drops of water. Did the water come through the vessel? Where did it come from? See fig. 19-3 in chapter 19.

Though we cannot see it, water vapour is always present in air. Recall the disappearance of water from puddles, pools, and ponds; from earth; from the leaves of plants (*General Science*, Book I, experiment 2-10), and from drying clothes. Recall the reappearance of water on grass blades in the morning, or on cold water pipes. Throughout the year, water from tea-kettles, from steam engines, and from the breath of all living animals disappears into the atmosphere. Then we see it again as mist, or rain, or frost on our windows.

How does water become invisible? Energy from the sun or from any other source of heat gradually changes a drop of water into particles (molecules) so tiny that they are carried away by the air as invisible water vapour. The change from liquid to vapour is called *evaporation*. Evaporation is hastened by heat, by dryness of the atmosphere, and by wind. Consequently, the amount of moisture in the atmosphere near the earth's surface increases constantly on warm, windy days.

Air containing much water vapour is said to be *humid*. In hot weather, humid air makes us feel warmer. On a cold winter day, out of doors, we feel colder when the air is humid than when it is dry.

A Review

The air of the atmosphere is a mixture of gases—about 78 per cent nitrogen, nearly 21 per cent oxygen, and about 1 per cent carbon dioxide and other gases—with a variable amount of water vapour. To these may be added such impurities as dust and germs.

Read the following "recipe" for making air: "Put four-fifths of a cup of nitrogen into a small jar. Add one-fifth of a cup of oxygen. Put in a pinch of carbon dioxide, a dash of water, and a little dust. Cover and shake the jar well."

Burning Changes Air Chemically

Where do things go when they burn? Do they just burn up? Scientists have shown that there is nothing lost when substances burn. They are merely changed into other substances. When charcoal burns, it uses up some oxygen, as our candle did. When the charcoal has burned away, there is little ash left. However, if we could have collected all the smoke and gases produced, they, with the ash, would weigh the same as the original piece of charcoal together with the oxygen that was used to burn it. We shall now try to find out what really does happen when things burn.

What Does Burning Produce?

EXPERIMENT 9-9. *What substance in fuels burns and forms heat?*

Hold a cool dish in a flame. Rub off some of the black deposit. This is carbon. Because it came from the flame, the carbon must have been present in some form in the candle. The dish cooled the carbon enough to prevent it from burning. See fig. 9-3,A.

EXPERIMENT 9-10. *What waste product does carbon form when it burns?*

By means of a wire handle, lower a lighted candle into a jar. Cover the jar with a piece of glass. When the candle has stopped burning, remove it quickly. Immediately pour a little limewater into the jar and replace the glass. Shake the jar well. What change is there in the limewater? The milky colour shows the presence of carbon dioxide, as we proved in experiment 9-5. This invisible gas is formed when carbon burns. Study fig. 9-3,B.

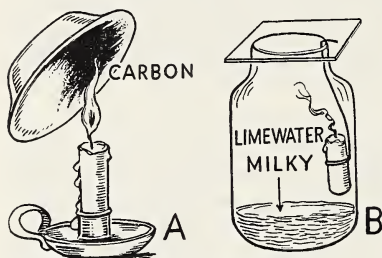


FIG. 9-3. CARBON IN FUEL BURNS TO PRODUCE CARBON DIOXIDE.

A. Carbon from the flame collects on the cool dish. B. Burning used up the oxygen in the air and produced carbon dioxide.

EXPERIMENT 9-11. *What other waste substances are formed when a candle burns?*

Hold a dry, cold tumbler over a burning candle, and another dry, cold tumbler over a hot iron, as shown in A and B of fig. 9-4. Observe the beads of moisture formed on the inside surface of the tumbler held over the burning candle. Such beads of moisture are not formed

on the inside of the tumbler held over the iron. Repeat the experi-

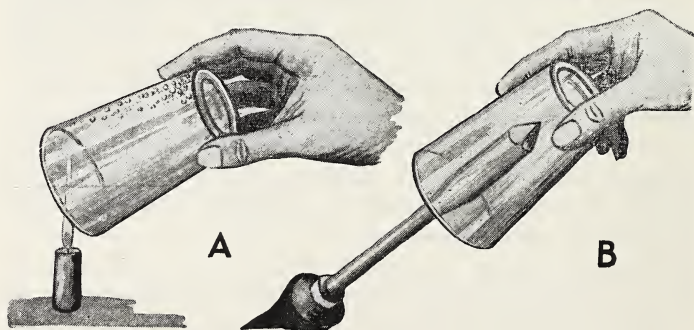


FIG. 9-4. BURNING PRODUCES WATER VAPOUR.

Beads of moisture in A, but not in B, show that water vapour was produced by the flame, but not by the hot iron.

ment, using the flame of burning wood, gas, or coal oil, and notice the beads of moisture. Most substances form water when they burn.

Rusting Is a Form of Burning. Iron left in a damp place soon becomes coated with a red substance called rust. By weighing a piece of iron before and after it rusts, we can show that the rusted iron is heavier than the original iron. Some substance must have been added to the iron to produce the rust. An experiment will show what this substance is.

EXPERIMENT 9-12. *What makes iron rust?*

Wet the inside of a tumbler. Sprinkle iron filings into it so that they adhere to its sides, or press some steel wool into the bottom of the tumbler. Turn the tumbler upside down in a dish of water (fig. 9-5,B). Invert a similar, but empty, tumbler beside the first tumbler (fig. 9-5,A). Leave both tumblers there several days. Notice the level of the water in each tumbler when the experiment is begun, then from day to day for several days.

Does water enter either tumbler? Which? What change can you see in the iron filings or in the steel wool? What fraction of the tumbler became filled with water? This experiment shows that the rusting of the iron used something from the air in the tumbler. Now study fig. 9-5,C.

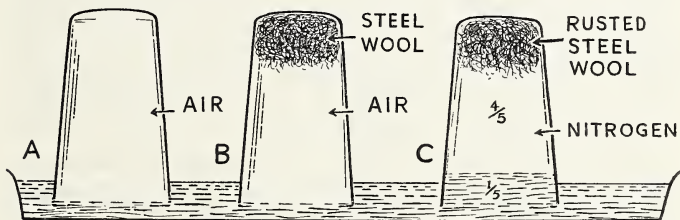


FIG. 9-5. THE RUSTING OF IRON IS SIMILAR TO BURNING.

A. The air remains unchanged. B. Steel wool exposed to moist air. C. As the steel wool rusted, it used up about one-fifth of the air, namely, the oxygen in it.

What did the rusting of the iron take from the air? Lift the tumblers, one at a time, from the water and immediately insert a blazing splinter into each. Did burning continue in the tumbler without steel wool? In the tumbler with steel wool?

Because the splinter did not continue to burn in the tumbler with steel wool, we know that this tumbler did not contain oxygen. The rusting of the steel wool used up the oxygen that was in the air in this tumbler. Therefore, the process by which iron rusts in the presence of oxygen is similar to the burning of a candle, but it is a very slow kind of burning.

Chemical Changes. We have seen that the burning of a candle and of fuel produces carbon dioxide and water vapour. Both of these gases are invisible.

Carbon dioxide is made up of carbon and oxygen. It is produced when carbon in fuel combines with oxygen in air during burning. Water vapour consists of hydrogen and oxygen combined. It is formed when hydrogen in fuel combines with oxygen in air during burning.

Oxygen is a simple substance that cannot be divided into any other substances. For this reason, we call oxygen an element. Scientists have been able to discover fewer than 100 such simple substances or elements. The carbon in a diamond or in coal, the nitrogen in air, the chlorine used to chlorinate water, and such substances as copper, lead, and calcium are elements. All substances that we know are made up of one or more elements.

The carbon dioxide in air consists of the two elements, carbon and oxygen, combined or united together to form one new substance. For this reason, we call carbon dioxide a *compound*. Carbon dioxide always contains the same proportions of carbon and oxygen. Water is called a compound because it consists of hydrogen and oxygen combined. The oxygen in water always weighs eight times as much as the hydrogen in it. Any compound always contains the same elements combined in the same proportions.

Whenever burning takes place, carbon combines with oxygen to form carbon dioxide. The combination of oxygen and carbon to form this new substance is called a *chemical change*. Burning is always a chemical change. The rusting of iron in air is a chemical change, too, because the iron combines with oxygen to form a new substance known as iron rust.

Other Ways in Which Air Can Be Changed

Air Expands When It Is Heated. Air can be changed in several ways without making any new substance, that is, without causing any chemical change. We can heat air or cool it without making any new substance. A thermometer shows that air changes in temperature. This is a *physical change*. Heating and cooling causes changes in the volume of air. An experiment will show us how.

EXPERIMENT 9-13. *How do heating and cooling change the volume of air?*

(a) Blow up a balloon a little, not enough to remove all the wrinkles. Hold the balloon over a stove or a hot radiator. What happens to the wrinkles? How does the balloon change in size?

Now leave the balloon in a cool place for a while. How does cooling change the size of the balloon?

(b) Fill a quart sealer with hot water. Invert a "pop" bottle, containing air only, into the hot water. Leave it there (fig. 9-6,A). Watch for bubbles escaping from the mouth of the bottle. After an hour, notice the level of the water in the neck of the bottle.

Why did some air soon bubble out of the bottle inverted in hot water? Why did water later rise in the bottle?

When air is heated, it requires more space. We say it *expands*. If the air can occupy more space in its container, it does so; if there is no more space to be filled, the air overflows, as shown in our experiment by the bubbles escaping from the mouth of the pop bottle.

Air Can Be Compressed.

Some of the air in a tire, a football, or a balloon escapes as soon as an outlet is made. This happens because the air within the container is under greater pressure than the air of the surrounding atmosphere.

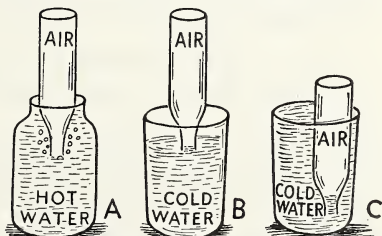


FIG. 9-6. AIR CAN BE CHANGED IN VOLUME. A. Air expands when heated. B. Air fills the bottle. C. The air, compressed by the deep water, occupies less space in the bottle.

EXPERIMENT 9-14. *Show how air can be compressed.*

Invert a "pop" bottle with its mouth under water. Notice how far the liquid enters the bottle. Push the bottle downwards vertically until it is almost submerged. Did the water enter it farther? Why? See fig. 9-6,B and C.

The air in the bottle requires space. The amount of space required depends upon how much the air is pressed. When the bottle was pushed deeper into the water, the water pressure at its mouth and neck became greater. This increased water pressure pushed the air in the bottle into a smaller space. The greater the pressure on air, the smaller the space it occupies. Change of pressure on air and by air is a physical change.

Air Forms Solutions. When we leave a tumbler of cold water where it will become warmer, some bubbles of air collect on the inside of the glass. This air had been *dissolved* in the water. We say it was *in solution*. More air can be dissolved or held in solution in cold water than in warm water.

Fish breathe the air dissolved in the water of a stream or an aquarium. As the water becomes warmer, it holds less air in solution and is, therefore, less favourable for fish. We may add air to the water by stirring it or by dipping it out and pouring it in again through the air. Waterfalls and rapids help fish by adding more air to the water. Green plants in a stream or an aquarium also add oxygen to the water. For this reason, we do not need to change the water in an aquarium if it contains water plants and is kept in a light place.

Air Is a Mixture of Gases. We have discovered that air contains the elements, oxygen and nitrogen, and the compounds, carbon dioxide and water vapour. It does not always contain these substances in the same proportions. Burning may use up some of the oxygen of air and increase the amount of carbon dioxide in it. In daylight green plants are constantly using up some of the carbon dioxide in air. Bacteria on the roots of clover may remove some of the nitrogen. A puddle of water or steam from a kettle, may add water vapour to air, but a cold window may take some away. Thus we see that air is something

like sand on a beach. It is a *mixture* of several different kinds of substances, sometimes in one proportion, sometimes in another.

Things To Do

1. Put a tablespoonful of baking soda in a pint bottle. Add half a glass of water. Shake the bottle well. Add some vinegar. The bubbles contain carbon dioxide.

Tip the bottle sideways and insert a blazing splinter or a lighted match into it. The flame goes out because the carbon dioxide prevents further burning.

2. Put a drop of vinegar on the shell of an egg. The bubbles you see contain carbon dioxide.

3. To find out whether a soft drink contains carbon dioxide, pour a few drops of the liquid into limewater. Does the limewater turn milky?

4. Find out how oxygen is used to restore health, to weld metals, and to make flying possible at high altitudes.

Test Questions

1. What substance is formed when carbon is burned?
2. How is breathing like burning? How is rusting like burning?
3. Why does fanning a fire make it burn more vigorously?
4. What two gases are produced when a candle burns?
5. How can we make carbon dioxide?
6. Why do people sometimes lower a burning lantern into a deep well before going down into it?
7. Why would a candle burning in a jar go out if a piece of dry ice were placed in the jar?
8. What three gases are always present in air?
9. State four uses of oxygen.

Your Word List

Oxygen, carbon dioxide, nitrogen, evaporation, humid, expands, compressed, solution, dissolve, mixture, element, compound.

16 mm. Sound Films

Ontario Visual Education Branch

Oxygen (SC-10)

10

AIR AND HEALTHFUL BREATHING

TO LIVE, we must breathe, eat, rest, and exercise. Without breathing, however, our food would be useless, our exercise impossible, and our rest unnecessary—for we could not live. To breathe, we must have air; to breathe healthfully, we must have good air. In this chapter we shall find out how breathing depends upon air, how it uses air, and how we can be assured of healthful air for breathing.

Breathing Changes Air

Living Animals Change Air by Breathing.

EXPERIMENT 10-1. *What does breathing take from air?*

Partially fill a pail with water. Lower a pint jar into the water until the jar is filled, then invert the jar. Push a rubber tube well up into the jar, then force your breath through the tube until all the water is driven out of the jar. Slide the hand under the jar and press the palm over its mouth to serve as a stopper. Lift the jar from the pail. Turn the jar upright again, still closed, and place it on a table. Immediately lower a blazing taper or stick into the jar. At the same time, have a helper lower a similar taper into a similar jar containing ordinary air. Which flame goes out first? Why?

The lack of oxygen in the exhaled air caused the flame in it to go out first. Breathing had used up the oxygen in the air.

EXPERIMENT 10-2. *What does breathing put into air?*

Half fill a small tumbler or bottle with limewater. Breathe into the liquid through a straw (fig. 10-1,A). How does the limewater change in colour? As carbon dioxide is the only substance that will make clear limewater become milky, we conclude that there was carbon dioxide in the breath.

EXPERIMENT 10-3. *Was all of this carbon dioxide in the air before we breathed it?*

As shown in fig. 10-1,B, pump some air through limewater in a bottle for the same length of time as you breathed through it in experiment 10-2. Does the limewater become as milky as when you breathed through it? Did the air breathed into the limewater in experiment 10-2 contain more carbon dioxide than the air around us which we inhale? How, then, does breathing change air?

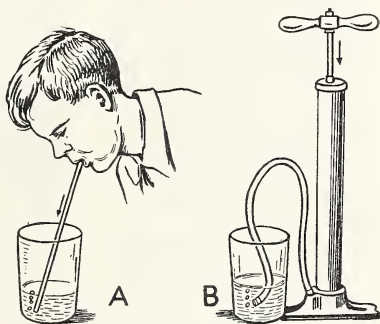


FIG. 10-1. BREATHING ADDS CARBON DIOXIDE TO AIR.

A. The breath makes limewater milky very rapidly, showing that we breathe out much carbon dioxide. B. Ordinary air makes limewater milky very slowly, showing that it contains little carbon dioxide. Carbon dioxide is added to air in our lungs.

You may wonder how carbon dioxide gets into our breath. When carbon, alone or in coal or other fuels, burns in air, carbon dioxide is formed. Breathing is really a slow kind of burning by which carbon in our food unites with oxygen in the air we inhale and forms carbon dioxide as a waste product. At the same time, enough heat is produced to keep our bodies warm, and enough energy of another kind to keep us active. To obtain enough oxygen to keep up this burning process, we breathe out the impure air and breathe in fresh air 15 to 20 times a minute. The air breathed out contains about a hundred times as much carbon dioxide as the air breathed in.

EXPERIMENT 10-4. Does breathing add water to the air?

Breathe against a dry mirror or dry eye glasses. Why does the glass lose its clearness? Rub off the misty spot with a finger. What was rubbed off?

The mistiness on the glass consisted of tiny droplets of water. This water came from the breath and condensed on the cool glass.

Living Plants Breathe and Change Air.

EXPERIMENT 10-5. How do germinating seeds change air?

Place some soaked corn or bean seeds in the bottom of a wide-mouthed jar. Leave the jar in a warm place until the seeds germinate. Place a small bottle of limewater in the

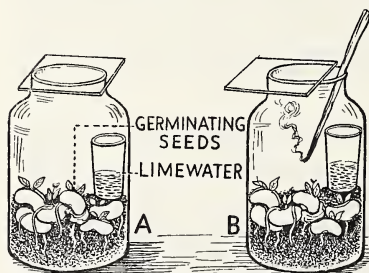


FIG. 10-3. GERMINATING SEEDS PRODUCE CARBON DIOXIDE.

A. The milkiness of the limewater left in the jar overnight shows that the germinating seeds produce carbon dioxide. B. Because the blazing splinter stopped burning in the jar, we know that the germinating seeds used up the oxygen of the air.

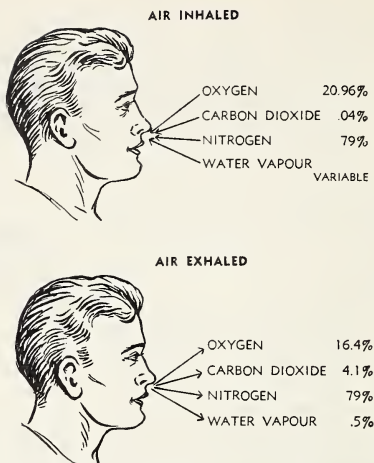


FIG. 10-2. HOW BREATHING CHANGES AIR.

jar, cover the jar tightly, and leave it overnight. How does the limewater change? Do the germinating seeds give off carbon dioxide?

Insert a blazing splinter into the jar. Does the splinter continue to burn? Why not?

Review the results of this experiment by studying fig. 10-3.

The germinating seeds used up oxygen and produced carbon dioxide.

They did this by breathing. All living things breathe all the time, and, to do so, they need oxygen. Fish take oxygen from the air dissolved in water. The carbon dioxide they breathe out also dissolves in the water.

Comparison of Burning with Breathing

	Burning	Breathing
Fuel needed	Wood, gas, oil, etc.	Digested foods
Cause	Oxygen in air	Oxygen in air
Useful products formed	Heat	Body heat and energy needed for bodily activities
Waste products	Ashes, carbon dioxide, and water vapour	Carbon dioxide and water vapour

How We Breathe

Breathing is to our bodies what the burning of fuel is to an engine. Our bodies are warm and active; a working engine is warm and active, too, but only as long as it burns fuel. The same is true of our bodies. The fuel used in our bodies is that part of our food that has been digested and taken into the blood. This fuel, like all others, will burn only with the help of oxygen. The necessary oxygen enters our blood through our lungs. Just as fuel and oxygen combine in an engine to give heat, so our digested food combines with oxygen in the blood stream to produce body warmth and the energy with which we move and work.

How Oxygen Gets to the Blood. The air we breathe carries oxygen to the blood. This air enters the nostrils, then passes down the windpipe and the bronchial tubes into our lungs (fig. 10-4,A). From the lungs, the oxygen is carried by the blood to all parts of the body (fig. 10-4,B).

Our lungs are made up of numerous tiny air sacs, each with a thin wall containing fine blood vessels. When air is breathed into the lungs, it swells all the air sacs until they have a total surface area of more than a thousand square feet. Through the thin walls of the air sacs, the air gives up some of its oxygen to the blood. In the blood, the oxygen combines with digested food to produce heat and the energy needed for bodily activity.

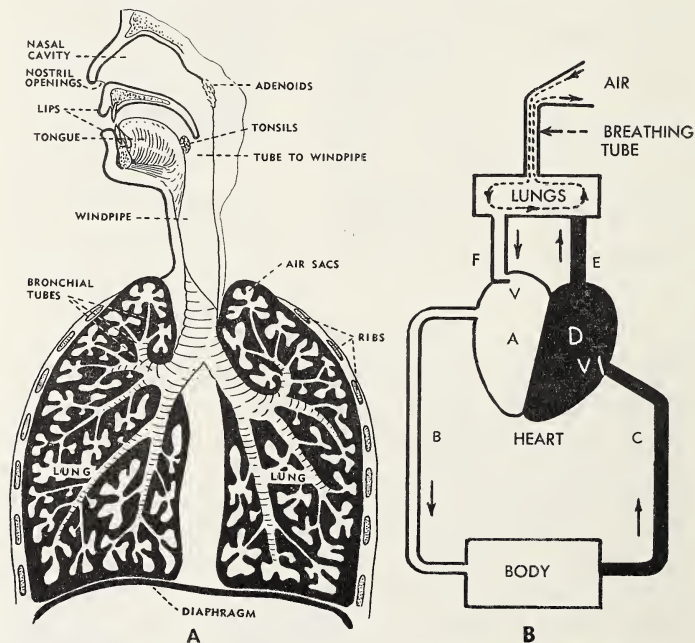


FIG. 10-4. BREATHING AND CIRCULATION WORK TOGETHER.

A. Follow the pathways of the air from the time it enters the nostrils until it reaches all the air sacs of the lungs. B. The lungs purify the blood that has been pumped throughout the body by the heart. Face a mirror as you study this drawing; then it will show you the direction of circulation of your blood. Blood vessels that carry blood to the heart are called veins; those that carry blood from the heart are called arteries. The black tubes in the diagram represent impure blood on its way to the lungs. The valves (V) close each time the heart is compressed. As a result, the blood cannot flow backwards, but must always flow forwards, as shown by the arrows.

To understand how oxygen is transported by the blood, we need to learn about the round, checker-like rafts, called red corpuscles, floating in the blood stream (fig. 10-5). These red corpuscles collect oxygen in the lungs and deliver it to all parts of the body. When we know that there are about five million red corpuscles in a drop of blood the size of a pin-head, we realize how tiny and numerous they are. Their redness is due to a colouring material called haemoglobin, a very important part of healthy blood. Because haemoglobin cannot be formed without iron, we should eat such foods as egg yolk, red meat, and spinach, which contain iron.

When food and oxygen combine to produce energy, they also form carbon dioxide and water. If the carbon dioxide accumulates, it poisons the system. The red corpuscles prevent poisoning by collecting the carbon dioxide and carrying it to the lungs.

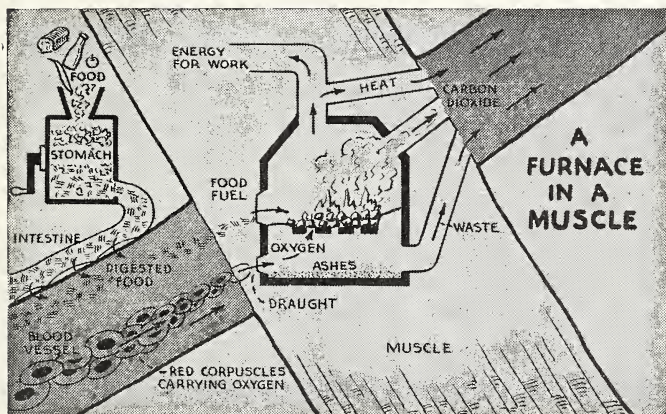


FIG. 10-5. HOW HEAT AND ENERGY FOR WORK ARE PRODUCED IN THE BODY.

Eating, breathing, and circulation all work together for our good. In this imaginary furnace the digested food is "burned", using oxygen carried by the red corpuscles. How does the food get to this furnace? What is the draught? What corresponds to smoke from a furnace? What are the useful products of the "burning"? How is the heat distributed?

When the red corpuscles carry much oxygen, they give the blood a bright red colour. When they are loaded with carbon dioxide, the blood is a darker red.

The blood serves as a transport in still another way. Sometimes we run on a cold winter day to keep warm. The muscles of our limbs then produce more heat as well as more energy of motion. As the blood circulates, it carries the heat from the muscles to the most distant parts of the body, somewhat as the water in the pipes of a hot-water heating system carries heat from the furnace (figs. 10-4 and 10-5).

Review what you have learned by studying fig. 10-5 and answering the questions given with it.

Getting Rid of Waste Products. The carbon dioxide and water vapour that we breathe out as waste products are collected by the blood stream. From the blood, they pass through a thin membrane into the air sacs of the lungs. From the lungs, they are breathed out through the windpipe and nostrils.

As long as we live, oxygen must continue to pass from the lungs to the blood, and carbon dioxide and water must pass from the blood to the lungs. How important it is, then, that we have the lungs examined at regular intervals to detect any abnormal condition that requires treatment.

Healthful Air for Breathing

The air we breathe should be comparatively warm, sufficiently moist, and comparatively free from dust and other impurities. In addition, it should be in constant circulation and frequently changed by ventilation.

The Air We Breathe May Be Unhealthful. The air in our classrooms and homes may keep us from doing our best work and help to cause colds and other common illnesses. The air has these effects when it is either too warm or too cold, or too dry or too moist. Dust, germs, and harmful gases may make air poisonous as well as unhealthful. Figure 10-6 shows how germs of tuberculosis may be passed from one person to another.

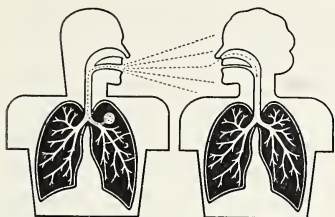


FIG. 10-6. AIR MAY SPREAD
DISEASE GERMS.

Bacteria from an infected lung may be carried by the air; then it may be breathed into, and infect, a healthy lung.

when we are working, and slightly higher when we are not active. At a temperature of 55°F. to 60°F. the air is warm enough for very hard work or for active games and exercises. When our surroundings are too hot, we lose ambition; when they are too cold, we use energy trying to keep warm.

In the next chapter, we will learn how we maintain the most healthful temperature by regulating our heating systems. Modern methods of insulating our buildings also help to keep the air in them at the right temperature in both winter and summer.

Keeping the Air Clean. The air everywhere always contains some dust. We can see this dust floating in the air when we direct a beam of light from a flashlight through a dark room or barn. We find dust collected on furniture and floors although we dust them every day or two. The darkening of walls above warm-air registers and radiators is caused by dust lodging on the wall as the warm air carries it upwards.

EXPERIMENT 10-6. *What sorts of places contain most dust?*

Smear several small pieces of glass with vaseline. Leave them for a day or two in such places as: inside a closet, on a table, near a window, near an unpaved road, near a cultivated field. Compare the amounts of dust collected in these places.

The air in mountain regions and in forests contains less dust

Keeping the Air Comfortably Warm.

PUPIL INVESTIGATIONS. *Keep a temperature chart for a week.*

Include thermometer readings for every hour of each day. How is the air made warmer when necessary? How is it cooled when it is too hot?

Health specialists agree that the most healthful temperature is 67°F. to 68°F.

than the air in cities and by roadways. Similarly, less dust is present in the atmosphere in damp weather than in dry weather.

Dust comes from many sources. In the classroom, it comes largely from chalk and from soil carried by shoes. Air from busy highways and streets, from cultivated fields and eroded soil, from flour mills and factories, and from building and construction works contains large quantities of dust. This dust includes unburned carbon in smoke from improperly fired furnaces and engines, and particles worn from pavements, rubber tires, clothing, and household furniture. Other impurities in air include carbon dioxide breathed out by all living animals, pollen from flowers and trees, fumes from factories and mines, and coal gas from stoves and furnaces.

Dust in the air harms us as we breathe. Some of it lodges on the membranes of the nostrils and in the breathing tubes leading to the lungs. It is particularly injurious to us when it collects on the delicate membranes of the lungs. People who grind glass, cut stone, or work in coal mines suffer most from breathing dusty air.

We may reduce the amount of dust in the classroom by several means: by cleaning the blackboards and blackboard brushes with care, by avoiding mud whenever possible, by keeping the floors oiled or waxed, by using a sweeping compound, and by dusting furniture with a damp or oily cloth. Modern air-conditioning systems filter dust and other solid impurities from the air. The amount of dust in the air out of doors may be reduced by oiling roads and driveways, by washing pavements, and by operating heating systems in a manner that will reduce smoke.

Fortunately, Nature has provided our breathing organs with efficient dust collectors. The forest of hairs in the nasal cavities filters out much of the dust, pollen, and bacteria as air enters. The moisture on the surface of the air passages through the nostrils and down to the lungs themselves constantly collects dust and germs from air passing through. The hair and mucus in these places reduce the harm that might be caused by breathing dusty air.

Keeping the Air Sufficiently Moist. The air in which we live may be moist, dry, or very dry, depending upon the amount of water vapour in it. Even desert air contains a little water. Water is constantly being added to the air by evaporation from lakes and streams, and from soil and plants. Still the air around us may not contain enough moisture either for comfort or for good health.

Too little moisture in the air makes our skin, our throats, and our nostrils feel dry and uncomfortable. Our breathing passages are then more likely to become infected by germs causing colds, bronchitis, or pneumonia.

When the air contains half as much water vapour as it is capable of containing at a particular temperature, we say the humidity is 50 per cent. A humidity of 40 per cent to 60 per cent is best for health. Below 40 per cent, the humidity is said to be low; above 60 per cent, it is said to be high. A room containing dry air feels cooler at 70°F. than a room containing moist air at a temperature of 66°F. Therefore, by adding moisture to the air in our living quarters, we can save considerable fuel without sacrificing comfort.

In winter, the air in our homes is likely to be much too dry for our comfort and health. When cold air from out of doors is heated, it becomes capable of holding much more moisture than it brought in with it. We say the air becomes dry. To learn how dry or how moist air is, we use an instrument called a humidiguide.

Moisture can be added to dry air by several means: by keeping the water pan in a warm-air furnace filled, by leaving trays of water over radiators, by keeping the teakettle steaming, and by installing special air-conditioning equipment. To be healthful, the air in each room of a house requires about a gallon of water a day.

Keeping the Air in Circulation. Stale air makes us uncomfortable, is injurious to our health, and lowers our efficiency. It is likely to lead to dull thinking and, perhaps, to headache. Stale air is more likely to contain disease germs. In contrast,

fresh air makes our breathing more efficient, causing us to feel fresh and ambitious, and promoting clear thinking.

PUPIL INVESTIGATIONS. *Is there a constant circulation of air in your room?*

Does a ventilating system bring air into your room through one register and take it out through another? If not, is there regular ventilation by opening windows at top and bottom? What other means of ventilation is employed?

A person in an air-tight room would soon use up a large part of the oxygen in the air and change it to carbon dioxide. The air would become "stuffy", and in a few hours there would be so much carbon dioxide and so little oxygen in the air that it would be unfit for breathing. For this reason, it is essential that the air in our living quarters be changed constantly or frequently by ventilation.

As we have discovered (experiment 10-4), breathing also adds moisture to the air. Air that contains too much moisture from breathing is undesirable. If disease germs are breathed out by ourselves or by others in an unventilated room, these germs are likely to spread disease.



FIG. 10-7. VENTILATE YOUR SLEEPING ROOM.

Fresh, cool air entering the lower opening replaces warm, stale air which leaves through the top opening.

We ventilate our living quarters to let stale air out and fresh air in. An outlet from the room and an inlet into it are required for these changes. If there is sufficient breeze, an open door or window on opposite sides of a room will ventilate it, but the resulting sudden change in temperature may be unhealthy. Therefore, other methods of ventilation become necessary in cold weather. A window may be opened slightly at both the top and bottom. Warm, stale air goes out through the upper opening, and cold, fresh air enters through the lower. As the cool, fresh air becomes heated, it circulates throughout the room. As it circulates, it gradually becomes more impure, rises, and escapes again. Thus, in a properly ventilated room fresh air is constantly entering and stale air constantly leaving the room.

Circulation of air within a room is essential in both winter and summer. In cold weather, the circulating air distributes heat evenly to all parts, and at all levels, of the room and contributes to our comfort and health. In warm weather, air circulation cools us. The layers of air next to the body become laden with water vapour from perspiration, and with carbon dioxide from breathing. As the air circulates, it replaces this moist, foul air with drier, fresh air. This drier air then evaporates more moisture from the skin than the moist air could. Because evaporation requires heat, the fresh air takes heat from the body and makes us feel cooler. In fact, the evaporation of a pint of water from the surface of the skin has as much cooling effect as the melting of seven pounds of ice.

Circulation of air is brought about by using electrical fans, fireplaces, heating equipment, and air-conditioning systems.

Air Conditioning. Think of a day in June, healthful and comfortable. The temperature may be the ideal of about 70°F. The air may be pleasantly moist, containing about half as much moisture as is possible at that temperature. There is little dust or smoke. A gentle breeze keeps the clean air moving by us. Air-conditioning systems make the air in our homes much like the air of such a June day.

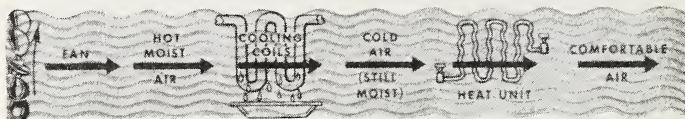
An air-conditioning system in a school, home, or office building provides all four conditions mentioned above. The air is circulated by a powerful fan operated by an electric motor. This fan draws impure air from the rooms into the air-conditioning machine and distributes the purified air back into the rooms. At the same time some fresh air is usually brought into the system. Dust, germs, smoke, and other impurities are filtered from the air as it passes through oiled glass-wool or other filters of very fine mesh.

In winter, the air is heated to the desired temperature as it passes over hot coils or around the firebox of a warm-air furnace. At the same time the correct amount of moisture is added to the air by means of a fine spray. In summer, the air is cooled to the desired temperature as it is forced through a cooling unit. Excessive moisture is removed from the air to lower its humidity.

WINTER AIR CONDITIONING



SUMMER AIR CONDITIONING



(From Compton's Pictured Encyclopedia)

FIG. 10-8. MAKING AIR HEALTHFUL BY AIR CONDITIONING.

Winter Air Conditioning. As the cold, moist air from out of doors is forced past the heating coils to make it comfortably warm, it becomes too dry for good health. Therefore, the air is forced through a water spray to make it healthfully humid.

Summer Air Conditioning. As the hot, moist air from our living quarters is forced past the cooling coils to make it less humid by removing some of its water vapour by condensation, the air becomes too cool for comfort. Therefore, it is heated to a healthful temperature before being forced back to our living quarters.

Cultivate the Following Healthful Breathing Habits

1. Play outdoor games and sports to strengthen the muscles used in breathing and to improve blood circulation.
2. Stand and sit correctly. This gives the chest more room for expansion. Rest your hands on your ribs and notice the difference in rib expansion when you throw back your shoulders and inhale.
3. Always breathe through your nostrils so that the air may be purified, moistened, and warmed before passing through the lungs.
4. If you are working in a very dusty place, protect your lungs by wearing a handkerchief over your nose.

Things To Do

1. Ask your teacher or the school janitor to explain to you how your school is ventilated.
2. Discuss in class: how stale air in the classroom may make pupils become restless; the advantages of frequently opening the windows and taking exercise.
3. Prepare and deliver a sales talk such as might be used to sell an air-conditioning system.

Think of These

1. Why is it harmful to the lungs when a person sits or stands with his shoulders slouched forward?
2. Why is breathing through the mouth less healthful than breathing through the nostrils?
3. How does the human breathing system resemble a heating and air-conditioning system in a home?
4. Why is indoor air often unhealthy although it is at the right temperature? How can the unfavourable conditions be corrected?

A Test

In the lists given below, each word or group of words at the left is closely related to a word or group of words at the right. Re-arrange the items so that related words or groups of words are opposite each other.

- | | |
|---------------------------------------|---|
| 1. products of breathing | 1. formed when fuels burn |
| 2. ventilation | 2. body heat and energy |
| 3. carbon dioxide and
water vapour | 3. getting rid of stale air |
| 4. carbon dioxide | 4. keeping air at the right temperature,
healthfully moist, and in circulation |
| 5. humidity | 5. turns limewater milky |
| 6. air conditioning | 6. amount of water vapour in air |

Your Word List

Humidity, circulation, ventilation, air conditioning.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Blood—The Life Stream of the Body", Vol. B, pp. 207-210; "Lungs", Vol. KL, pp. 351; "Breathing, the Mainstay of All Life", Vol. QR, pp. 117-118.

16 mm. Sound Film

Ontario Visual Education Branch

Mechanism of Breathing (animated drawings) (H-14)

UNIT FOUR

Fire, Servant and Master

11. *FIRE AS MAN'S SERVANT*

Although fire produces power and enables us to smelt and shape metals, it serves most of us best by heating our homes. Heat is produced by many kinds of fuels and in various types of heating systems, but always with the help of air. Heat becomes useful to us only when it has been brought from the fire to our living quarters—through metals, by conduction; through water and air, by convection; and out from hot objects, by radiation. How convenient for us that we have thermometers and thermostats to measure and to control heat.

12. *FIRE AS MAN'S ENEMY*

When fire is not controlled, it may cause destruction to property, and pain or death to man and to wild and domestic animals. Preventing fires by knowing and taking proper precautions with camp fires, fuels, heating systems, electricity, gasoline, and other hazardous substances is wiser, safer, and less costly in suffering and money than trying to extinguish them by applying water to them, smothering them, or using fire extinguishers. Every week of the year, at home and at school, should be a Fire Prevention Week.



11

FIRE AS MAN'S SERVANT

FIRE WAS NOT KNOWN to earliest man; he had never seen it. What a strange experience for some prehistoric man when, by accident, he first saw fire and felt its warmth! Did he fear it or welcome it? We do not know. How difficult it must have been for him to learn to use it safely. Having once found this new, magic "substance", he worshipped it on his altars, taking every precaution never to let its flames go out.

Early man had good reasons for guarding fire well. To his cave or primitive shelter, it added warmth and cheer; at night, it scared away savage beasts that lurked nearby; at mealtime, it made his wild vegetable foods and his meat more palatable. Little wonder early man worshipped fire on his altars!

Fire is essential in modern living. In the home, it gives warmth and comfort, and enables us to cook and use a greater variety of foods. In industry, it makes available to us such necessities as cement and lime, glass and brick, metals and machines, lard and soap. Fire makes travel possible whether by automobile or train. It contributes to our health by killing germs, preserving food, and disposing of refuse.

Fire Heats Our Homes

Conditions Necessary for Burning. Heat is produced by fire, and fire is produced by burning fuel. We have learned that fuels

contain carbon, and that this carbon is the part of the fuel that burns. The carbon burns by combining with oxygen in the air, and heat is produced by this chemical change.

To have a fire, however, we must know how to start it. A boy scout can start a fire by rubbing two sticks together until a spark is produced. This will light some dry, decayed wood, then some dry leaves and twigs. Since civilization dawned in Egypt about 6,000 years ago, fires have been started by striking together two pieces of flint, or a piece of flint and a piece of iron or steel. The blow knocks off tiny white-hot particles which can set fire to dried grass or any other easily lighted "tinder". A flint and steel and a tinder box were the prized possessions of nearly every household from the time Champlain was exploring new-found Canada until our forefathers had settled Old Ontario. How convenient, in comparison, are the modern cigarette lighters and matches that we use today. They are both quite recent developments, although the cigarette lighter works on the principle

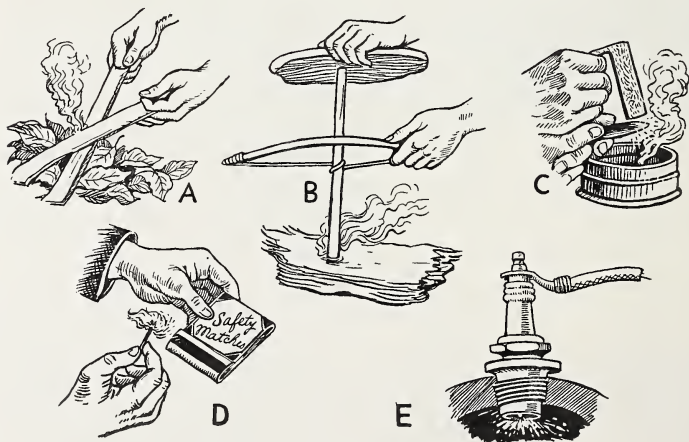


FIG. 11-1. WAYS OF MAKING FIRE.

A, rubbing sticks together until friction produces a spark; B, Eskimo bow drill used to rotate a stick until its end, pressed against wood, becomes hot and ignites the ground wood; C, flint and steel struck together to produce a spark; D, safety matches; E, spark plug, used in gasoline engines.

of the old tinder box and contains a flint and steel. Simple as our modern matches may seem, they are a more recent invention than both the steam engine and the telegraph.

Review what you have read by studying fig. 11-1.

Two conditions necessary for burning are fuel and oxygen, as we learned in chapter 10. The fuel may be of any kind, for all fuels contain the carbon needed for burning. But air must always be present since carbon cannot burn without oxygen.

EXPERIMENT 11-1. *Does the amount of air present influence burning?*

Attach three short candles a few inches apart near the centre of a large plate. Pour water into the plate. Light the three candles. Obtain a small tumbler, a large tumbler, and a pint sealer. With the help of a classmate, invert the three glass containers over the three candles at the same time. Which candle stops burning first? Repeat the experiment, inverting each jar or tumbler over a different candle than before. Why does the candle under the smallest vessel always stop burning first? How does the amount of air present affect burning? Compare your observations with those indicated in fig. 11-2.

Fuels do not begin to burn as soon as they come into contact with air. If they did, most of the things we need in everyday life would be burned up, for most of them contain carbon and could be classified as fuels, and they are also surrounded by air, containing oxygen. We shall discover presently that heat is the third condition necessary to start fuel burning.

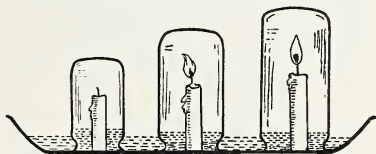


FIG. 11-2. BURNING REQUIRES AIR.
The greater the amount of air (and, therefore, oxygen) available, the longer burning continues.

Our experiences in making a campfire, or a bonfire for a corn roast, teach us the essentials of making a fire. First, we gather a supply of fuel, probably dry pieces of wood which will burn readily, give enough heat, and last well. It is difficult, however, to start a fire with wood alone, so we place paper and dry twigs under the edge of the main fuel, then apply a lighted match to the paper.

When the match is “struck”, a little flame is formed by the union of the chemicals in the head of the match with oxygen in the air. The heat of this little flame warms the matchwood close to it, and this begins to burn. The temperature to which this wood must be heated before it burns is known as its *kindling temperature*. The heat of the burning match warms the paper to its kindling temperature, and it burns, aided by the surrounding air. The burning paper warms the twigs to their kindling temperature, and they begin to burn, giving more heat than the burning paper gave. The burning twigs heat the larger pieces of wood to their kindling temperature, and they burn. In every instance, oxygen in the air helps in the burning. The rate of burning is increased by a breeze, or by blowing onto a fire, for these feed more air to the fire.

We have now learned that the three conditions necessary for fires to burn are: (1) the presence of substances that will burn easily and give heat, namely fuel; (2) a source of heat to warm the fuel to its kindling temperature; (3) a constant and adequate supply of air to provide the oxygen needed for burning to start and continue. These are illustrated in fig. 11-3.

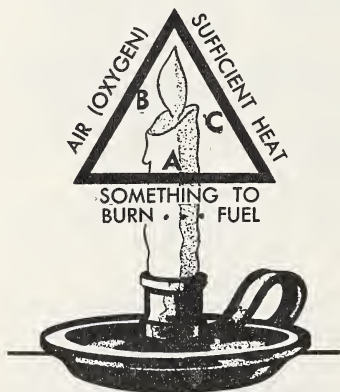


FIG. 11-3. THE RED TRIANGLE. Just as any triangle must have three sides, so this triangle illustrates the three conditions necessary for burning.

EXPERIMENT 11-2. *Do all fuels require the same kindling temperature to start to burn?*

Arrange the following in line on a fireproof surface: a candle, a twist of paper, the head of a match, a piece of cloth, a piece of pine wood, a piece of oak, and a lump of coal. Apply a burning match or a lighter to each. Which starts to burn in the least time? Which requires the most heat to start to burn? Arrange the substances in order of ease of lighting so that the first substance has the lowest kindling temperature and the last substance has the highest.

EXPERIMENT 11-3. Find out how a candle burns.

(a) Light the tip of the wick of a candle. Observe carefully the changes that follow. How does the wax change when the flame of the wick reaches it?

(b) Blow out the candle. Immediately apply a burning match to the whitish smoke above it. What happens?

The whitish smoke contained vapour from wax that had melted and travelled up the wick. Heat changes the hot liquid wax to wax vapour. The vapour combines with oxygen in the air and burns, producing heat, carbon dioxide, and water vapour.

(c) Hold a small stick horizontally in the middle of the flame of a candle until the wood begins to burn. Remove the stick and blow out the flame. Examine the stick to see whether it was burned chiefly at the edges of the flame or in the middle of the flame. Is the flame of the candle the same colour at its edges as in the middle? How does fig. 11-4 explain why the stick burned where it did?

The outer part of a candle flame is hottest because it obtains more oxygen. The inner part of such a flame is not hot enough to burn either the vapour or the wick (fig. 11-4,B).



FIG. 11-4. WHAT HAPPENS IN A CANDLE FLAME?

A. The match burned and charred only where the hot, outer part of the flame was in contact with it. B. The wax of the candle melts, travels up the wick, and vapourizes—then the outer part of the vapour, well supplied with air, burns.

EXPERIMENT 11-4. *What causes a fire to smoke?*

Gradually lower a tumbler over a burning candle while watching the flame. Notice the streams of smoke in the tumbler and the soot on the glass. The smoke and soot consist of carbon set free from the vapour of the melted wax without being burned. Lack of oxygen prevented this carbon from burning.

Why does a stove or a furnace smoke sometimes when you close the draught door or open the check damper in the pipe leading to the chimney? Why does running with a candle or blowing against its flame make it smoke and go out?

EXPERIMENT 11-5. *Why does a burning candle or a fire give light?*

Hold a knife-blade in the flame of a candle. What collects on the blade? From what part of the flame do these black particles come? The black particles on the knife-blade consist of soot, a form of carbon. These soot particles collected on the blade in the brightest part of the flame. There they were heated red-hot and glowed in the same manner as the heated element in an electric light bulb glows, giving forth light.

Common Heating Systems. Early man had very simple ways of making the heat from fire serve him. A bonfire in the open was the most primitive method. As we know today, such a fire is hard to control, and much of the heat from it is wasted in the surrounding air where we cannot use it. Then man learned to build his fire in an enclosed space such as a cave, a hut, or a tepee. The walls helped to conserve the heat while the smoke escaped from the entrance or a hole in the top.

The invention of the open fireplace, with its chimney, made it possible to control the draught to the fire and, therefore, the rate of burning. With the fireplace, more of the heat from the fire became useful (fig. 11-5,A).

The Stove. With the invention of the firebox to enclose fire, the first stove was made. Stoves require less attention, cause less dust and smoke, and are more convenient than fireplaces for cooking. They waste less heat through the chimney and warm the surroundings more uniformly than do fireplaces.

The Warm-air Furnace. The simplest kind of central heating system is the warm-air furnace. It is merely a large stove surrounded by a metal case in which air is heated. From this case, the warmed air is distributed through pipes and registers to all the rooms in the house. The air from a warm-air furnace is made healthfully moist by keeping the water pan inside the metal case of the furnace filled with water. Study fig. 11-5,C.

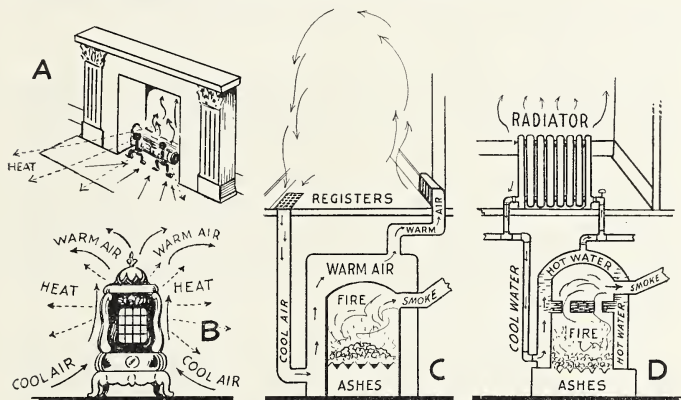


FIG. 11-5. WAYS OF OBTAINING HEAT.

A. Fireplace. Solid lines show air circulating towards the fire and up the chimney. Dotted lines show heat radiated outwards from the fire in all directions.

B. Stove. Solid lines show air circulating towards, beside, and above the stove. Dotted lines show heat radiated outwards from the hot stove in all directions.

C. Warm-air Heating System. The arrows indicate the paths of circulating air.

D. Hot-water Heating System. The arrows show the courses followed by the circulating water and the upward air currents.

In comparison with stoves, furnaces distribute heat more evenly throughout the house and are much cleaner.

The pipeless furnace is a simple type of warm-air furnace, with but one pipe leading to a register in the room above. The pipeless furnace is usually placed under the centre of the main room of a house. If more than one room is to be heated, the warm air must gradually circulate from room to room.

The Hot-water Heating System. A hot-water system of heating a home differs little from a warm-air system except that warm water rather than warm air carries the heat from the fire to our rooms. Surrounding the firebox of the hot-water furnace is a space always filled with water. When the water in this space is heated, it circulates up through pipes from the furnace to the radiators in the rooms. The hot radiators, in turn, heat the surrounding air. The cooled water returns from the radiators to the furnace. Study fig. 11-5,D.

In comparison with the warm-air heating system, a hot-water system keeps our living quarters at a more uniform temperature, and both the furnace and the water pipes last much longer without repairs. However, this system has some disadvantages. Some of these are: its initial high cost, its inability to give quick changes in temperature, its failure to add any moisture to the air in our rooms, and the danger of the water in the pipes freezing if left unheated in cold weather.

The Steam Heating System. In this system, some of the water in the boiler surrounding the firebox is changed to steam. This is forced, under pressure, through pipes and radiators to the rooms. When the steam in the pipes and radiators is cool enough, it condenses and once more becomes water. This water flows back through the pipes to the boiler.

A steam heating system is best for a large building and for several buildings heated from a central plant. Radiators heated by steam cool quickly as soon as the fire is too low to produce more steam.

The Radiant Heating System. This very modern kind of heating system warms our homes somewhat as the sand on a beach, when heated by the sun, warms the air above it. Hot water or steam is forced through pipes embedded in the floor or the ceiling of a room. The hot pipes heat the whole surface of the floor or ceiling. Then this surface heats the air in the room. Because the heat is *radiated* out from the warm floor or ceiling

to all parts of the room, we speak of this method of heating as *radiant heating*. Radiant heating is clean, healthful, and economical.

Fuels. As time marches on, man discovers or prepares new fuels, and then invents new heating devices with which to use them.

PUPIL INVESTIGATIONS. *Fuels and how they burn.*

1. Let each pupil report in class what kinds of fuels are burned in the stove or furnace, or both, at home. What kinds are used at school? What is the present price of each kind? Individual pupils may consult parents, and a class committee may interview janitors and fuel dealers, to find out which fuels will heat homes and larger buildings most cheaply, and which with the the least inconvenience or labour. Discuss the findings in a class conference.

2. Find out what fuels your grandparents burned. Why? Why are many homes in counties along Lake Erie heated by natural gas? In what other places do we find homes heated by this fuel?

3. Observe the burning of different kinds of fuels. Make a class chart recording information concerning the amount and the colour of the flame of each kind of fuel; the amount of smoke and of ash or clinker each forms; the speed with which each produces heat; and the length of time each burns.

A good fuel starts to burn at a low temperature, continues to burn freely, and gives large amounts of heat while burning. The fuels most commonly used are wood, hard and soft coal, coke, oil, and gas.

Wood and Charcoal. Wood is still man's commonest fuel where trees are plentiful. It kindles easily when dry and produces heat quickly. However, it requires large storage space and gives an uneven heat, much of which goes up the chimney.

The chief use of charcoal, made from wood, is to start fires.

Coal and Coke. Hard coal (anthracite) is popular because it forms little dust, burns with little smoke, gives an easily-controlled heat, and lasts well. Offsetting these advantages is its high price. Soft coal (bituminous) costs less than hard coal and has a high heat value, but it is dirty and smoky, and its fire requires a great deal of attention. It is more useful to man if it

is first changed to coke. Coke also is cheaper than hard coal and gives a quick, hot fire with little smoke. However, it does not burn long and its fire requires frequent attention.

Gas and Oil. Both natural and artificial gas are used for fuel. They require special burners in stoves and furnaces. In regions where natural gas is plentiful, it is a cheap fuel. Fuel oil, made from petroleum, must be changed to vapour and mixed with air before it will burn; consequently, it requires special oil-burning equipment. The desired temperature is obtained by using a thermostat to control the rate at which the oil is burned. The main advantages of using gas or oil as fuel are the uniform temperature which they provide and the convenience of not having to stoke the furnace or remove ashes.

Fuels Must Be Conserved. When fuel is burned, it is gone forever; it can never be replaced. The known resources of coal, petroleum, and gas are limited, and some of these are already being exhausted. Although we are finding new sources of fuels, such as the petroleum fields in Alberta, the time will come when all resources have been found.

Conservation of fuels means wise use of them. We may save fuel by several methods: by operating stoves and furnaces efficiently, thus reducing the waste of heat through the chimney; by insulating our buildings, thus reducing loss of heat through ceilings and walls; by turning off the source of heat in unoccupied rooms and in those being ventilated; and by keeping the temperature of our living quarters down to approximately 68°F. Coal gives us more heat if we first change it into coke and gas. Therefore, it is more economical for us to use it in these forms. The use of thermostats and other automatic heat controls for the operation of central heating plants and furnaces helps to save fuel. We also conserve fuel when we use water power or atomic energy instead of coal to generate electricity. What a help it would be if, some day, scientists were to find ways of using the sun's rays, in place of fuel, to warm our homes.

Answer These

1. What three conditions are necessary for burning?
2. Why is it more difficult to start a fire with hard coal than with wood or charcoal?
3. How does a heating system using warm air differ from one using hot water?
4. What is smoke?
5. Why does smoke go up a chimney?
6. In what ways does black smoke from a chimney show waste of fuel?
7. Of what is the soot in a pipe or chimney composed? What is its source? How could soot cause a fire?
8. How may fuel be saved at your school? At your home?

How Heat Travels from Fire to Room

The heat from the fire in a stove or furnace must reach all parts of our living quarters if it is to serve us best. Heat travels through the firebox by *conduction*; it travels to our rooms in moving air or in moving water by *convection*; it is given out from hot radiators by *radiation*. We shall now try to discover how heat travels in these three ways.

Heat Travels by Conduction. The fire in a stove or in the firebox of a furnace is enclosed by a metal case. First, we should find out how the heat gets through this metal to the air or water surrounding it.

EXPERIMENT 11-6. *How does heat travel through metal?*

Hold a silver spoon or a piece of iron wire in a cup of hot water. What do you feel? Does the metal continue to become warmer?

Heat passed from the water into the metal, then it moved gradually through the metal, heating every part as it travelled. We say the metal *conducted* the heat ("conduct" means "lead"), or that the heat travelled by *conduction*.

Heat travels by conduction from the fire in the stove or furnace through the enclosing metal wall to the air or water surrounding it. Likewise, the metal of a teakettle and its handle, and the metal of a stove poker, conduct heat to the hand.

EXPERIMENT 11-7. *Do all substances conduct heat equally well?*

Repeat experiment 11-6, placing a pencil and a silver spoon of the same length in the hot water, both at the same time. Which conducts heat to the fingers more efficiently? Feel the wood, then the metal, of your desk. Which feels cooler?

Metals conduct heat better than wood. For this reason, the spoon became hot, but the pencil did not. The metal of a desk conducts heat away from the hand faster than the wood can, and therefore the metal feels colder although it is actually at the same temperature. Glass, like wood, is a poor conductor of heat.

Substances that are poor conductors of heat are called *insulators*. The wood in the knob of a teakettle is a good insulator. Air is a poor conductor of heat. Therefore, wool, sawdust, ground cork, and rock wool, all containing much air, are good insulators.

Questions

1. Why is an air space left between the brick and the inside plaster of a house?
2. Why does loose snow help to keep the soil from freezing?
3. Why does hot water cool faster in a tin cup than in a glass tumbler?

Heat Is Carried by Convection Currents of Air or Water.

Now, we shall try to find out why warm air from the registers of a warm-air heating system, and the heated air near hot radiators, circulates throughout a room.

EXPERIMENT 11-8. *In what part of a room is the air warmest?*

With a thermometer, measure the temperature of the air near the ceiling, half way up, and near the floor of a room at home or at school. Compare the temperatures.

EXPERIMENT 11-9. *In what directions do air currents move in a warm room?*

Hold a smoking rag above a warm-air register, above a hot radiator, in front of a hot radiator, near the opening of a window open at the top, and near the opening of a window open at the bottom. In what direction is the air moving in each of these places?

Heat and cold determine the directions in which air currents move. Warm air always seems to move upwards, and cold air downwards. These movements cause some of the air to move sideways.

EXPERIMENT 11-10. *Why does warm air rise?*

Put a cork or a match in a soup plate. Pour in some water. Why is the cork or the wood lifted up? Yes, because it is lighter than water. Similarly, warm air is lighter than cool air and is lifted up by it.

When cold air comes into a space containing warmer air, or warm air comes into a space containing colder air, the colder air, being heavier, moves under the warmer air and lifts it up. This may be a little difficult to understand. You will recall that in experiment 9-13 we discovered that air expands when it is heated. Therefore, when the air in a box measuring a cubic foot is heated, some of it overflows and escapes from the box. The air left in the box then weighs less than the original boxful of air. Therefore, a cubic foot of warm air weighs less than a cubic foot of colder air. Because warm air is lighter than cooler air, it is always lifted up by cooler air moving under it.

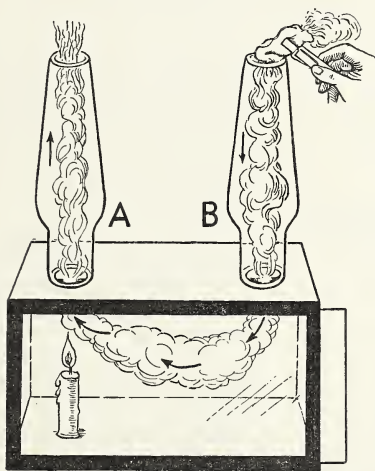


FIG. 11-6. CONVECTION CURRENTS IN AIR.

The cooler, heavier air continues to move down chimney B and across through the box, pushing the warmer, lighter air up chimney A and producing a continuous convection current of air.

EXPERIMENT 11-11. *Why does air go up a chimney?*

Turn a chalk box on its side so that the lid faces you. Cut two holes, each about an inch across, in the upper side of the box (fig. 11-6). Place a glass (or paper) chimney over each hole. Replace the wooden lid with a piece of glass. Open this glass lid and place a burning candle under chimney A. Close the glass again. Hold a piece of smouldering rag over chimney B. Which way does the smoke move? With a thermometer, take the temperature of the air in each chimney. In which is the air warmer? Compare your observations with those illustrated there.

The air in chimney A expanded as it was heated. Therefore, it became lighter than the air in chimney B. As a result, the cooler, heavier air in chimney B pressed down and across through the box, forcing the warmer air in chimney A upwards. This created a steady current of air in the direction indicated by the smoke. Such a current is called a *convection current*.

A warm-air heating system heats a house by means of convection currents, as shown in fig. 11-5,C. The air inside the case around the firebox of the furnace becomes heated and expands. Then it is lighter than the cooler air in the pipes that return air to the furnace from the rooms above. As a result, the cooler, heavier air pushes the warmed air up through the warm-air pipes to the rooms above as a continuous current of air. When the warm air reaches a room, it keeps on moving upwards, forced up by the cooler air in other parts of the room. This, too, creates a constantly moving current of air, a convection current.

Find the lines indicating convection currents in air in fig. 11-5,A,B,C, and D.

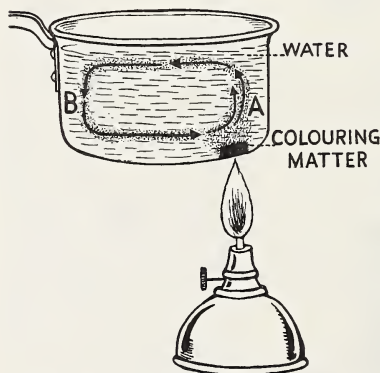


FIG. 11-7. CONVECTION CURRENTS IN WATER.

The cooler, heavier water at B continues to move downwards and across the saucepan, pushing the warmer, lighter water at A upwards and forming a continuous convection current in the water.

EXPERIMENT 11-12. *Why does the hot water in a hot-water heating system circulate to the radiators in the rooms?*

Put water in a saucepan. Place the pan over a flame or on a stove so that only one edge of the pan is heated. Place a drop of red ink, a piece of indelible lead, or some other soluble colouring matter in the water just over the source of heat. Notice the current of coloured water—up over the source of heat, across the surface of the water, down the other side, and back across the bottom again. Study fig. 11-7.

As the water over the heated part of the pan (experiment 11-12) became warmed, it expanded and became lighter than the cooler water at the other side of the dish. The cooler, heavier water pushed downwards and across the pan, and forced the warmer, lighter water upwards. This started the water circulating in currents as shown in the diagram. These currents, like those in the air, are called *convection currents*.

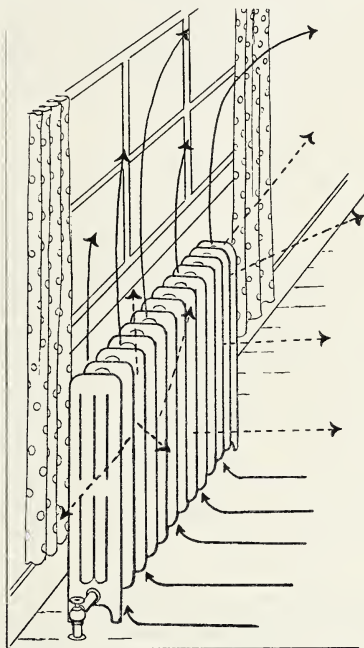


FIG. 11-8. HOW A HOT RADIATOR HEATS A ROOM.

A. By Convection. The solid lines illustrate convection currents of air towards the base of the radiator and up from its top.

B. By Radiation. The dotted lines indicate radiation of heat outwards from the radiator in all directions.

EXPERIMENT 11-13. *Show that cold water pushes up hot water.*

Fill a milk bottle with cold water, coloured with red ink. Fill a similar bottle with hot water. Press a paper over the bottle of cold water and carefully invert this bottle over the one containing hot water. Slide out the paper. What does the coloured water do? Cold water settles under and pushes up warm water because the warm water is lighter.

In a hot-water heating system, the water next to the firebox is heated, expands, and becomes lighter. The water in the pipes from the rooms, cooler and heavier, pushes under the hot water and forces it up the radiators. This movement continues as a convection current of water.

Now trace the course of the convection currents of water in fig. 11-5,D.

Heat Is Distributed by Radiation.

EXPERIMENT 11-14. *Heat can travel in all directions without a conductor or convection currents.*

Plug in an electric toaster, or turn on an electric light bulb. Feel the heat above it. Some of this heat is carried to the hand by convection currents. Feel below and beside the hot toaster or bulb. How does the heat you feel there get to the hand?

Any hot object—a toaster, a radiator, a stove, an open fire, an electric heater, or the sun—sends forth heat rays in every direction, by *radiation*. Because these rays can pass through glass, we can feel heat from the sun inside a window. Radiated heat travels in straight lines, in all directions, and either with or without air.

A Review

Examine fig. 11-5, A, B, C, and D, also fig. 11-8, and find all the dotted lines indicating heat being radiated.

Heat that travels by radiation is called *radiant heat*. The heat from the sun, from heated sand on a beach, and from warmed soil is radiant heat. Radiant heat can pass through anything that is transparent—glass, water, air, even a vacuum—but it does not warm these as it passes through them. When radiant heat reaches the soil or a window sill, through which it cannot pass, it is absorbed, making the soil or the window sill warm. For this reason, radiant heat warms the earth's surface; the warm earth radiates heat outwards, and this warms dust and moisture in the air, making the atmosphere warm enough to sustain life. A ceiling or floor heated by a radiant heating system radiates heat outwards to all parts of the room.

How We Measure and Control Heat

Temperature determines how we heat our homes, what we wear, and the activities in which we engage. To measure temperature, we use thermometers; to help to keep our surroundings at the right degree of warmth or cold, we use thermostats and insulating materials.

Thermometers. A thermometer measures heat. A household thermometer measures the temperature of the out of doors or of the interior of buildings. Other types of thermometers are used

to measure the temperature of a person, of boiling syrup, and of materials used in scientific experiments.

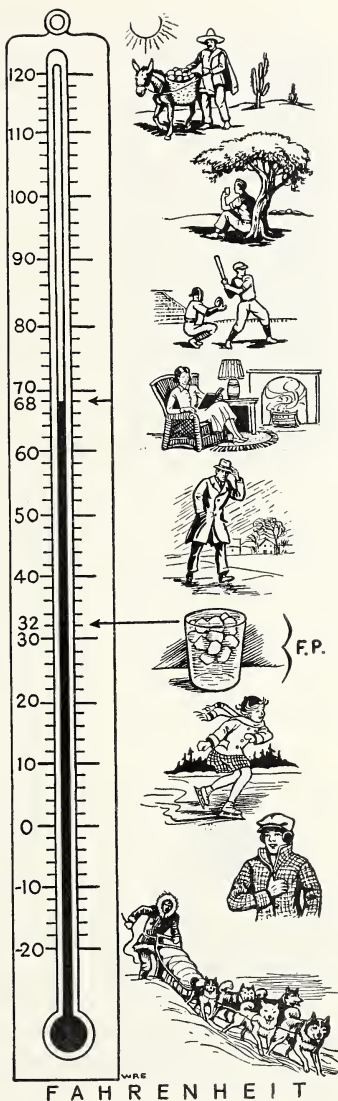
A thermometer consists of a narrow glass tube closed at the upper end and with a closed bulb at the lower end. The tube is made of thick glass with a fine, thread-like bore through it. The bulb and part of the tube is filled with mercury or with coloured alcohol. The space in the tube above the liquid contains no air: it is a *vacuum*.

The height of the mercury or alcohol shows us the temperature of whatever material surrounds the bulb in the thermometer. The warmer the material, the higher the level of the liquid in the tube.

We measure temperature in *degrees*, just as we measure length in inches. The scale on the glass tube of the thermometer, or behind it, shows, in degrees, the temperature at the bulb.

FIG. 11-9. A FAHRENHEIT THERMOMETER.

As you study the various activities illustrated, notice the temperature at which each is likely to take place.



The scale of degrees on a thermometer is determined by two important temperatures, the *boiling point* of water and the *freezing point* of water. The boiling point is marked on the scale at the level of the alcohol or mercury when the bulb of the thermometer has been completely surrounded by steam from boiling water. Freezing point is marked at the level of the liquid in the thermometer when the bulb has been surrounded for a little while by a mixture of ice and pure water.

The scale on the household thermometer (Fahrenheit thermometer—named for its inventor) is labelled 32° at the freezing point and 212° at the boiling point. The thermometer used in scientific experiments (centigrade thermometer) has a freezing point of 0° and a boiling point of 100° . To indicate which kind of thermometer we have read, we write the temperature as 68°F . (Fahrenheit) or 20°C . (centigrade).

Fig. 11-9 will help you to understand a thermometer better.

EXPERIMENT 11-15. *Why does the liquid rise in a thermometer when heated?*

See fig. 11-10. Through the cork of an ink bottle, make a hole just large enough for a piece of glass tubing to pass through. Fill the bottle with coloured water. Push the glass tube just through the cork. Fit the cork tightly in the bottle. Attach a paper scale to the glass tube. Place the bottle in a dish of warm water. What happens in the glass tube? Why? Move the bottle to a dish of hotter water. What do you learn from seeing the water rise in the tube? How does this explain the working of a thermometer?

A thermometer can measure temperature because the liquid in it, like the water in our experiment, expands a definite amount for every increase of one degree in temperature, and contracts the same amount for every decrease of one degree in temperature.

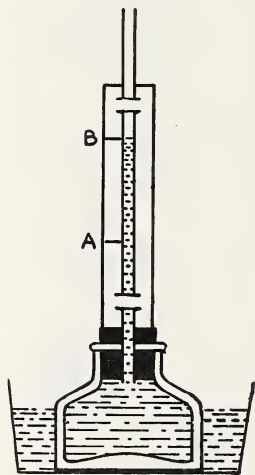


FIG. 11-10. HOW A THERMOMETER WORKS.

When the bottle was placed in warm water, the liquid rose from A to B in the glass tube. Why?

Water would not be suitable for a thermometer. Because it freezes at the freezing point and boils at the boiling point, it could not measure temperatures higher or lower than these.

Thermostats. The thermostat of a heating system is an instrument which can be set to provide any desired temperature in a building or room. It does so by turning heating equipment on or off, thus providing more heat or less heat. When the room is warmed to the temperature for which the thermostat is set, the thermostat turns off the electric current going to the motor that operates the oil burner or stoker. Burning is stopped. When the room becomes cooler than the set temperature, the thermostat starts the heating equipment operating again, providing more heat. Thermostats, whether used to control heat from coal, gas, oil, or electricity, produce a uniform temperature and, therefore, more healthful living conditions. See fig. 11-11.

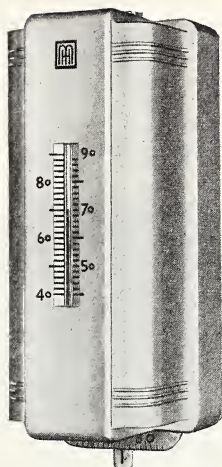


FIG. 11-11.

A THERMOSTAT.

By regulating heating equipment so as to maintain any desired room temperature, a thermostat safeguards our health and comfort, and saves labour and fuel.

Insulation. Substances that do not conduct heat well (insulators) may be used to keep heat in our homes in winter and to keep it out in summer. Insulation helps us to conserve fuel and adds to our comfort.

In cold weather heat escapes from a house in three ways. Some of it is conducted through the walls and the glass windows to the outdoors. Some of it escapes by convection in air moving past loose-fitting doors and windows, and up between the layers of the outside walls. Still more heat is radiated out in all directions from all outer surfaces of the house, for these are warmer than the surrounding air.

Air is such a poor conductor of heat that man is constantly finding new ways of using it to insulate his buildings. Mineral wool and rock wool are excellent insulating materials because of the tiny air spaces in them. Fig. 11-12 shows how much air is contained in a block of these materials. This imprisoned air keeps heat from passing through the materials.

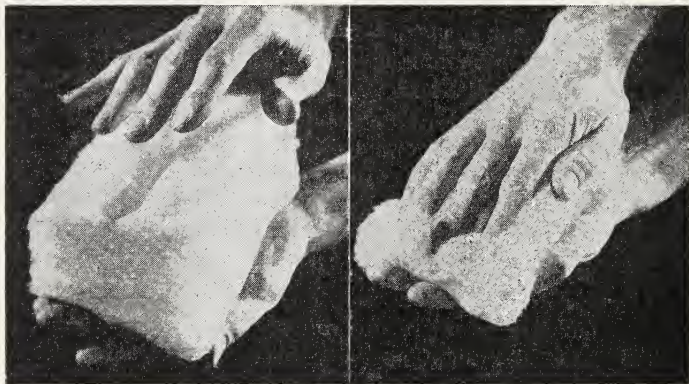


FIG. 11-12. MINERAL WOOL FOR INSULATION.

The difference in thickness of this mineral wool when compressed and when not compressed indicates the large amount of air it contains. This air makes the mineral wool an excellent insulating material.

Rock wool, or mineral wool, and similar materials may be spread between the joists of the attic floor, blown into the space between the outer and inner walls of a building, or applied in such places in the form of pads or batts two or three inches thick when the building is being constructed. Such layers of insulation prevent convection currents of air from carrying away heat. They also reduce the conduction of heat through the outside walls and the floor of the attic.

Several kinds of insulating wallboards are manufactured. These serve two purposes: they help to keep heat from passing in or out of the building; they form a base for the plaster of the inside walls.

Our homes are also insulated by the use of weather stripping, storm doors, and storm windows. Weather stripping prevents warm air from circulating outwards around doors and windows. Storm doors and outside windows imprison a layer of still air across which little heat escapes. They also prevent air draughts and air currents around the edges of inside windows and doors.

Things To Do

1. Discuss how convection currents help: (a) to keep the temperatures of all parts of a room nearly equal; (b) to ventilate a room; (c) to cause loss of heat.
2. List three ways of reducing the amount of heat lost from a house through and around windows.
3. Find the freezing point of alcohol and of mercury, and decide which liquid should be used in making a thermometer for the northern parts of Canada.
4. Mix a little alcohol or other anti-freeze material with water. Find the temperature at which the mixture begins to freeze.
5. Explain to your class the difference between a thermometer and a thermostat.

Test Questions

1. Why is the ice storage box of an ice refrigerator installed near the top?
2. Why is the air near the ceiling in a room warmer than the air near the floor?
3. What makes fresh air keep moving in towards a burning candle or a lighted lamp?
4. Why is a cork stopper instead of a metal lid used in a thermos bottle?
5. Why do mineral wool, asbestos, and insulating wallboards keep a house warmer in winter and cooler in summer?
6. Why does a wooden house lose more heat through the roof than through the walls in winter?
7. How do liquids change in size when heated? When cooled? How does a thermometer show this?
8. Why could coloured water not be used in a thermometer for outdoor use in Canada?

Your Word List

Tinder, kindling temperature, soot, warm-air furnace, steam heating system, radiant heating system, anthracite, bituminous, oil-burning equipment, conduction, radiation, insulator, insulation, convection current, vacuum, thermometer, thermostat, freezing point, Fahrenheit, centigrade.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "What Fire Is and How It Serves Man", Vol. F, pp. 77-79; "Indoor Comfort with Modern Heating", Vol. GH, pp. 321-326.

16 mm. Sound Films

Ontario Visual Education Branch

Measuring of Temperature (SG-52)

Ryerson Film Service

Transfer of Heat

12

FIRE AS MAN'S ENEMY

UNDER CONTROL, fire is man's faithful servant and friend, contributing much to his comfort. Out of control, or where he does not want it, it may be one of man's worst enemies, depriving him of much that he needs and enjoys. Most destructive fires are caused by man's ignorance or carelessness; therefore, most of them can be prevented by more knowledge and care. To prevent unwanted fires we need to understand the characteristics of substances that will burn readily, and we need to put forth every effort to see that these substances burn only when and where we wish them to burn.

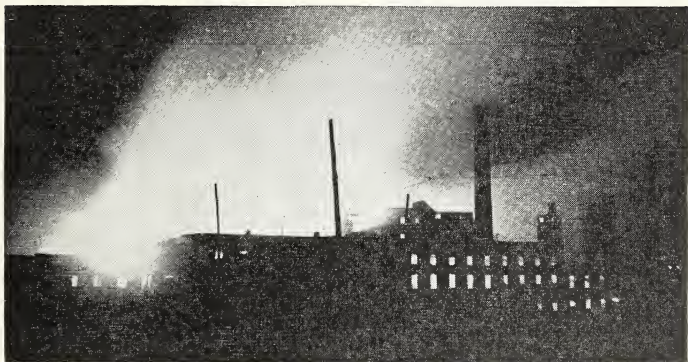


FIG. 12-1. FIRE, THE GREAT DESTROYER.

This fire caused losses valued at millions of dollars when it consumed Canada's largest match factory, a huge stockpile of wood to be made into matches, and the Interprovincial Bridge across the Ottawa River between Ottawa, Ontario, and Hull, Quebec.

How Fires Get Started

Once started, a fire is difficult to control or extinguish. To prevent fires from starting, we must know the conditions under which they do start, and then we must prevent these conditions from existing.

We have learned already that fuel and air are partners working together to produce fire. Fortunately, the partnership is successful only if the fuel is first heated to its kindling temperature. The fuel may be waste papers or rubbish stored in unsafe places, gas or vapours from gasoline, or fat or oil in a cooking utensil. Air containing oxygen is always at hand. The source of heat that warms the fuel to its kindling temperature and starts the fire burning may be any one of these: a match or a cigarette carelessly discarded before it is out, heat from a stovepipe or chimney too close to material that can burn, hot ashes or clinkers unsafely stored, defective electrical wiring, embers from a steam engine, or lightning. When we, through ignorance or lack of care, permit the three conditions necessary for burning to exist together, we may be responsible for starting a fire, costly in life and property.

How Fires May Be Prevented

We cannot control the air around us, but we can control one or both of the other two conditions that cause fires, namely, the materials that can burn, and the source of heat that starts the burning.

We Can Prevent Fires by Keeping Air and Combustible Substances Apart. Fire-resistant paint on wood does not ignite readily in the presence of fire. By keeping air from reaching the wood, the paint prevents the wood from burning for some time. When gasoline and other liquids that burn easily are stored in air-tight metal containers, neither air nor a spark can reach them. By keeping chimneys free from soot, we leave no fuel for the heat and air there to burn.

We Can Prevent Fires by Keeping Combustible Substances Where Heat Cannot Reach Them and Warm Them to the Kindling Temperature. A layer of metal or asbestos should separate a stove or furnace from any combustible material close enough to become hot. Important papers should be stored in a fire-proof vault of metal or concrete to keep them away from both heat and air. A fire-proof covering of asbestos, slate, or metal on the roof and sides of a building separates the combustible wood beneath it from any possible source of heat such as a flame or sparks. Furnace rooms are safer when we keep them clean and tidy, free from materials that start to burn easily.



FIG. 12-2.

ASBESTOS IS A GOOD INSULATOR. An asbestos suit keeps heat from reaching the man or his clothing.

We Can Prevent Fires by Controlling All Sources of Heat That Might Start Fuel Burning.

Hot ashes and clinkers, stored in metal containers, cannot set fire to nearby materials. Ash trays in our living quarters serve a similar purpose. Lightning rods direct the electric current down past the wood of a building into the ground, thus keeping the current from heating the wood on its way. A screen in front of a fireplace prevents hot cinders from reaching and igniting a rug. We need hardly be reminded of the importance of care in discarding matches and cigarettes that have been burning.

How Fires May Be Put Out

A fire cannot continue to burn if any one of the three conditions that started it burning is removed. It will burn only as long as it is provided with fuel, air, and a temperature as high as the kindling temperature of the fuel. Therefore, we can put out a fire by depriving it of fuel or air, or by cooling the fuel sufficiently.

Putting Out Fire by Using Water. Water is most commonly used to put out fire. It does so in two ways. First, water cools the burning material below its kindling temperature; then the fuel cannot continue to burn. Second, water keeps air from reaching the burning fuel, both by wetting the fuel and by producing steam which drives away the air.

EXPERIMENT 12-1. *How does water prevent things from burning?*

Spray water on burning paper. What happens? Wet all the paper. Hold a burning match or the flame of a candle or of a lighter close to one corner of the paper until the paper begins to burn again. How does the burning now compare with the burning before the paper was wet? What two changes took place in the wet paper before it started to burn again?

Water put out the fire by cooling the paper and by excluding air. The flame applied to the wet paper dried it, then warmed it to its kindling temperature before it started to burn again.

Putting Out Fire by Smothering It. A fire is smothered by preventing air from reaching it.

EXPERIMENT 12-2. *Will sand put out a fire?*

Build a small bonfire in a safe place in a yard. Throw some sand or earth over it. How does this affect the burning?

The sand or soil cut off the supply of air. It also cooled the burning material.

A fire dies when deprived of air. Stamping on a burning match or cigarette stops it burning by keeping air away from it. Wrapping a blanket around a person whose clothes are on fire, or rolling the person over and over on the ground, puts out the fire for the same reason.

The burning of gasoline, oils, and greases can only be stopped by excluding air. This may be done by covering the burning materials with sand or, better still, by using a fire extinguisher to cover the fire with carbon dioxide or with some other gas that excludes air. See fig. 12-3.

Water should not be used on burning gasoline, oils, or greases. Because these substances are lighter than water, they float on top of it. Not only will the fire continue to burn, but it may be spread by the water.

Fires in coal mines may be extinguished by smothering them. This is accomplished by sealing up the part of the mine in which coal is burning and thus excluding the air that is necessary for burning to continue.

Putting Out Fire by Depriving It of Fuel. We put out a fire when we turn off the gas leading to a gas burner (fig. 12-4), and when we let the fuel in a stove burn up. In each instance, we have deprived the fire of fuel. A grass fire is put out by digging a ditch round it, preventing the fire from reaching more grass.

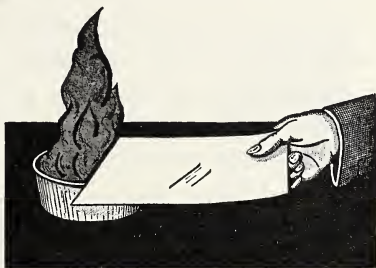


FIG. 12-3. SMOTHERING AN OIL FIRE. The fire of an oily rag burning in the dish was extinguished by sliding the card quickly over the smooth top of the dish.

NOTE. This experiment should be performed only by adults.

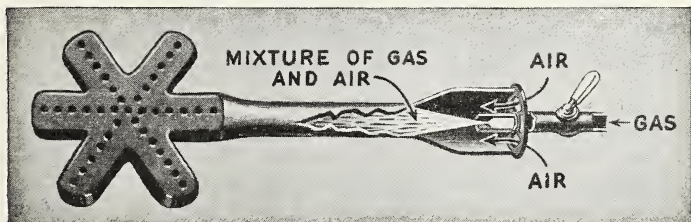


FIG. 12-4. TURNING OFF THE GAS PUTS OUT THE FIRE.

Forest fires may be extinguished by cutting a fire lane ahead of the fire. The absence of trees in this area keeps the fire from travelling farther. A bonfire may stop burning when the burning fuel is scattered, thus removing the fuel from the fire and cooling it below its kindling temperature.

Putting Out Fire by Using Fire Extinguishers. Fire extinguishers are efficient in putting out small fires. The equipment is easy to use and convenient to store.

EXPERIMENT 12-3. *Make a fire extinguisher.*

Obtain a fruit jar or a wide-mouthed bottle and a cork to fit it. Insert a glass tube a few inches long through a hole in the cork. Put two tablespoonsful of baking soda in the jar, and fill the jar one-third full of water (A). Half fill a small bottle with vinegar or with sulphuric acid. Carefully suspend the bottle in the jar in a vertical position by means of a wire (B). Insert the cork tightly.

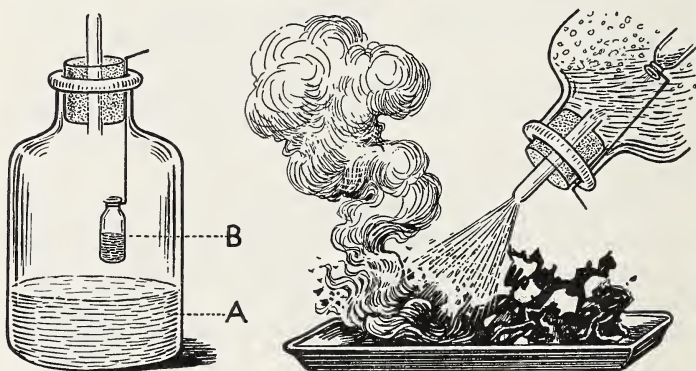


FIG. 12-5. A HOME-MADE FIRE EXTINGUISHER.

Carbon dioxide and the liquid excluded air from the burning paper, and the foamy liquid cooled the paper below its kindling temperature.

Ignite some paper in a metal dish or in a safe place in the yard. Tip the jar to spill the vinegar into the soda solution. Direct the gas and liquid escaping from the glass tube over the fire. What gas was produced? Give two reasons why the fire went out.

The soda and the vinegar or acid produced carbon dioxide. This gas formed enough pressure to force the foamy mixture of liquid and

carbon dioxide through the glass tube. The fire was put out because the liquid cooled the burning paper, also because the liquid and the carbon dioxide both excluded air.

The most common type of fire extinguisher is somewhat like the one you have made. It consists of a metal case with a nozzle as an outlet. The case contains a solution of baking soda in water, and a small upright bottle of sulphuric acid (fig. 12-6). When the fire extinguisher is turned upside down, the acid mixes with the soda solution and produces carbon dioxide. This gas creates enough pressure to force the foaming mixture of liquid and carbon dioxide out through the nozzle onto the fire. The liquid and the carbon dioxide put out the fire by cooling the burning material and by excluding air.

Other types of fire extinguishers contain a supply of carbon dioxide or of some other gas that will put out a fire. These gases are contained under pressure, ready to escape with considerable force when a valve is opened.

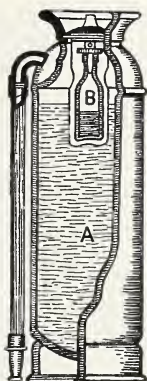


FIG. 12-6.

A SODA-ACID FIRE EXTINGUISHER.

A, a solution of baking soda in water; B, a bottle of sulphuric acid.

In Case of Fire!

We cannot always prevent fires. But we should be prepared for fires if they occur.

PUPIL INVESTIGATIONS. *Be prepared for fire.*

1. Locate the fire alarm box nearest each of these: your home, your school, other public buildings, such as churches and theatres, that you attend.
2. Learn how to send in a fire alarm.
3. Find the fire exits in your school, your church, and any theatre you attend.
4. Locate any fire extinguishers at home and at school. Learn how to operate them.

Doors in public buildings usually open outwards to permit people to escape easily and quickly in case of fire. Aisles and hallways leading to doors are kept clear for traffic. School fire drills are conducted from time to time to teach pupils the quickest and safest way of escaping from the building, and to train them to leave in an orderly manner.

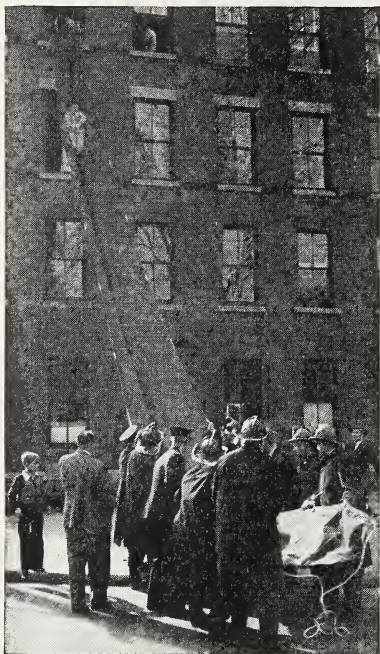


FIG. 12-7. A FIRE RESCUE CHUTE.

A student fireman of the Ottawa Fire Department testing this method of removing people from a burning building.

Act quickly when fire is discovered. Warn others. Notify the fire department. Leave all windows closed to prevent draughts. If you are last out, close all doors behind you, for the same reason.

To reduce harm from smoke, cover the nostrils and mouth with a wet cloth and crouch low. Treat slight burns with salve, vaseline, or oil to keep air from the wound, but leave all serious burns for treatment by a doctor.

Special Precautions To Prevent Fires

Safety with Fuels and Heating Equipment. Many fires originate in furnace rooms where fuels and heat are near each other. For this reason, the furnace should never be installed under stairs or corridors unless it is in a fire-proof room with a fire-proof door. Walls, ceilings, and floors of combustible material,

if near heating equipment, should be covered with metal or asbestos.

To prevent fires from being started by furnaces and stoves, we should take these precautions: keep the surroundings free from waste paper, rubbish, kindling, paints, and oils; do not allow stoves and pipes to become overheated. Such ordinary precautions as storing hot ashes and clinkers in metal containers, keeping the pipes of chimneys free from soot, and placing screens in front of open fireplaces must not be overlooked.

Fires are often caused by defective heating equipment. Stoves, furnaces, stokers, and oil burners should be inspected at regular intervals to detect any fire hazards. Pipes and chimneys should be kept clean and in good repair. Electrical outlets and wiring, also gas pipes, should be installed only by competent workmen.



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FIG. 12-8.

Stoves and furnaces should be operated in such a manner that poisonous coal gas does not escape from them. Fresh coal always contains some coal gas which will burn after being driven from the coal by heat. Coal gas obtains the air necessary for it to burn if the slide in the fire-door of the furnace or stove is left partly open. When putting in fresh coal, we should see that there is a spot of bright coals to ignite the coal gas as it is formed. If it is not ignited in the furnace, some of this poisonous gas will escape through the chimney or into the house. When in the air in large enough quantities, coal gas may cause death to those who breathe it.

Both natural gas and artificial gas (coal gas), commonly used as fuels, are very poisonous to man and other animals and to plants. Fortunately, these gases can be detected by their odour. To prevent their escape, we should make sure that there are no gas leaks in pipes or stoves, and take care that cooking vessels on a gas stove do not boil over and put out the flame, leaving unburned gas to escape. Modern stove burners are so constructed that spilled liquids do not put out the flame. Of course, we need not be reminded of the danger in lighting a match where there is the smell of gas!

Precautions with Matches and Cigarettes. Matches should be stored in containers that cannot burn, and should always be kept out of reach of children. Only safety matches should be carried. These can be lighted only by striking them against a special substance on the container. Of course, we should all cultivate the habit of breaking a match between our fingers before discarding it; then we will know it is out. It has been said: "Matches have heads, but no brains. When you use *their* heads, use your brains."

A careless smoker can cause death and destruction. Smoking in bed, about a barn, near explosives, or where there is gasoline or other easily ignited materials should never be allowed. The ash from a cigarette or a cigar should always be discarded where there is nothing to burn, never in a wastepaper basket or

on materials that ignite readily. The burning butt of a cigar or cigarette should always be crushed thoroughly to make certain that no fire is left in it.

Precautions in Using Electricity. Fires are often started by a spark or by heat from an electric current. Most of these fires may be prevented by making certain that electrical installations are safely made by a qualified electrician, by never operating too many appliances at one time on the same circuit, and by seeing that all fuses used are correctly chosen. Extension cords should never be kinked, hung on nails, or left for permanent use. Worn or bare electric cords of toasters and other electrical appliances should be repaired or replaced at once. The same applies to loose or faulty electrical connections.

Safety with Decorations. Because many decorations are made of materials that ignite easily, special precautions in their use are necessary. Decorations should always be kept at a safe distance from electric light bulbs and from other sources of heat. Special care is advisable with Christmas trees and the decorations on them. Of course, no open flames or lighted candles should ever be brought near a Christmas tree. In addition, all electric wiring used with the tree should be carefully inspected before being used. The needles of the Christmas tree itself may be kept fresh and less likely to catch fire if the base of the tree rests in a dish of water.

Dangers and Precautions with Fats, Oils, Paints, Lacquers, and Waxes. Fats and oils are ignited easily when heated and exposed to a spark or an open flame such as that of burning gas. Once ignited, these substances burn very rapidly and spatter about, often causing painful burns or costly fires. The wisest precaution is to make certain that no fat or oil can come into contact with a flame.

Paints, lacquers, and waxes burn readily. Therefore, they should be stored where they are safe from fire. For the same reason, any cloths containing oil, paint, or wax should be destroyed or placed in metal containers.

If any of these substances should start to burn, the fire must be put out by smothering it.

Dangers and Precautions in Using Gasoline and Petroleum Products. Gasoline evaporates easily and produces gasoline vapour which, when mixed with air, is ignited by a mere spark. The flames spread rapidly, and as far as there is a mixture of the vapour and air to burn. Frequently, the burning takes place as a violent explosion, destroying life and property.

The utmost precaution is necessary in handling and using gasoline. Stoves and lamps using this fuel must be handled with special care and strictly in accordance with directions provided with them. No open flame or smoking should be permitted near a place where gasoline is being handled or poured, as when filling the tank of an automobile. Needless to say, gasoline should never be used to start a fire, nor should it be used as a cleaning fluid. A spark caused by rubbing the fabric may ignite the vapour and cause an explosion. Gasoline should never be stored in barns or homes except in very small quantities, and then in plainly labeled, tightly closed containers.

PUPIL INVESTIGATIONS. *Safe cleaning fluids.*

Find out: what liquids are used in dry-cleaning plants; what safe cleaning fluids may be bought in local stores.



FIG. 12-9. EXTINGUISHING THE FIRE IN A BLAZING PIT OF WASTE OIL. Left, oil wastes burning violently; right, the fire put out in 30 seconds by a chemical fire extinguisher.

The care used in handling gasoline is necessary also in handling kerosene (coal oil), fuel oil, and other products made from petroleum. Stoves and lamps burning kerosene should be used with caution. Oil lamps should always be kept out of reach of children and should have such wide bases that they cannot be tipped over easily. The upsetting of a burning oil lamp may lead to a serious fire because the spilled oil vapourizes and burns very readily when brought into contact with a flame. For the same reason, kerosene should never be used to start fires or to kindle a smouldering fire. As we have learned, fires caused by the burning of gasoline or petroleum products can be extinguished only by being smothered.

Precautions To Prevent Spontaneous Combustion. Costly fires have been started by cloths containing paint or oil bursting into flame suddenly, but unexpectedly. Similar fires have started in hay or straw that has been stored while still damp. The cause of such fires is called *spontaneous combustion*. Combustion is merely another word for burning. "Spontaneous combustion" means "burning of its own accord".

EXPERIMENT 12-4. *To illustrate spontaneous combustion.*

Leave grass cuttings packed in a box for two or three days. Feel them. How do they change in temperature?

The grass clippings were warmed by chemical action taking place in them. Hay or grain stored in a barn when too green or too moist will also "heat".

Just as steel wool combined slowly with oxygen (experiment 9-12) to form rust, so linseed oil, green grass, damp hay, soft coal, and some other substances gradually combine with oxygen and produce some heat. If this takes place in a closed space, the heat cannot escape and gradually raises the temperature of the materials. At higher temperatures, the substances combine even more quickly with oxygen and produce more heat. If the cloth or other material becomes heated to the kindling temperature, it bursts into flame, often causing a destructive fire.

Inspect Your Home and School for Fire Hazards

Examine all parts of your home and school for possible causes of fire. Look especially for worn insulation and loose connections in electric wiring, unscreened fireplaces, electric bulbs or heating equipment too close to curtains or other combustible materials, and rubbish or inflammable materials in the furnace room. Make a list of any such fire hazards you find.

Remove any hazards that you can. Discuss in class the best methods of having the others removed.

Things To Do

1. Write to the Dominion Fire Prevention Association, Ottawa, and to the Department of Insurance, Government of Canada, for literature dealing with fire prevention for your classroom library.
2. Investigate the story of matches from their invention to the development of modern safety matches.
3. Find out how paper and cloth may be made fireproof.

Investigate and Report to Class

1. The merits of fire-resistant paints, and how they are applied.
2. The value of treating fabrics with fire-retarding chemicals.
3. Different kinds of fire extinguishers, how to use them, and how they work.
4. Organizations that carry out campaigns to help prevent fires.
5. The work of the Fire Marshal of your province, and provincial regulations for fire protection in public buildings.
6. The organization and activities of the local Fire Department.

For Discussion

1. Suggest reasons why more rural than city homes burn.
2. How does blocking up the passageway in a coal mine put out a fire farther in?
3. What makes a cigarette lighter in a car work? Why is it safer than matches or some other kind of lighter?
4. Why is it dangerous to use a match to check the level of alcohol anti-freeze in an automobile radiator?
5. Why do laws prescribe fire drills in schools?
6. Why do fire insurance rates vary with the kind of roofing and outside walls on a house?

Test Yourself

1. What conditions are necessary for a fire to start burning?
2. Why does fanning a fire make it burn better, whereas blowing on a lighted match puts it out?
3. In what ways may electrical equipment cause fires?
4. How would you extinguish the fire that is burning the clothes on a person? Why does this method succeed?
5. Why does covering a fire with sand put it out?
6. State three ways in which water puts out a fire.
7. How are "safety matches" safe?
8. Tell how each of the following is a fire hazard: an ordinary match, a discarded cigarette, coal gas, natural and artificial gas, gasoline vapour, fat or oil on a stove.

Your Word List

Hazard, precautions, artificial, vapour, kerosene, petroleum, gasoline, combustible, inflammable, spontaneous combustion, extinguish, insulation, kindling temperature.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Fighting the Dreaded Enemy — Fire", Vol. F, p. 85.

16 mm. Sound Films

Ontario Department of Lands and Forests

Who Was Guilty? (colour)

Ontario Visual Education Branch

Fire (animated drawings) (SG-9)

National Film Board of Canada

Coal Gas (animated cartoon) (colour)

Are You Safe at Home?

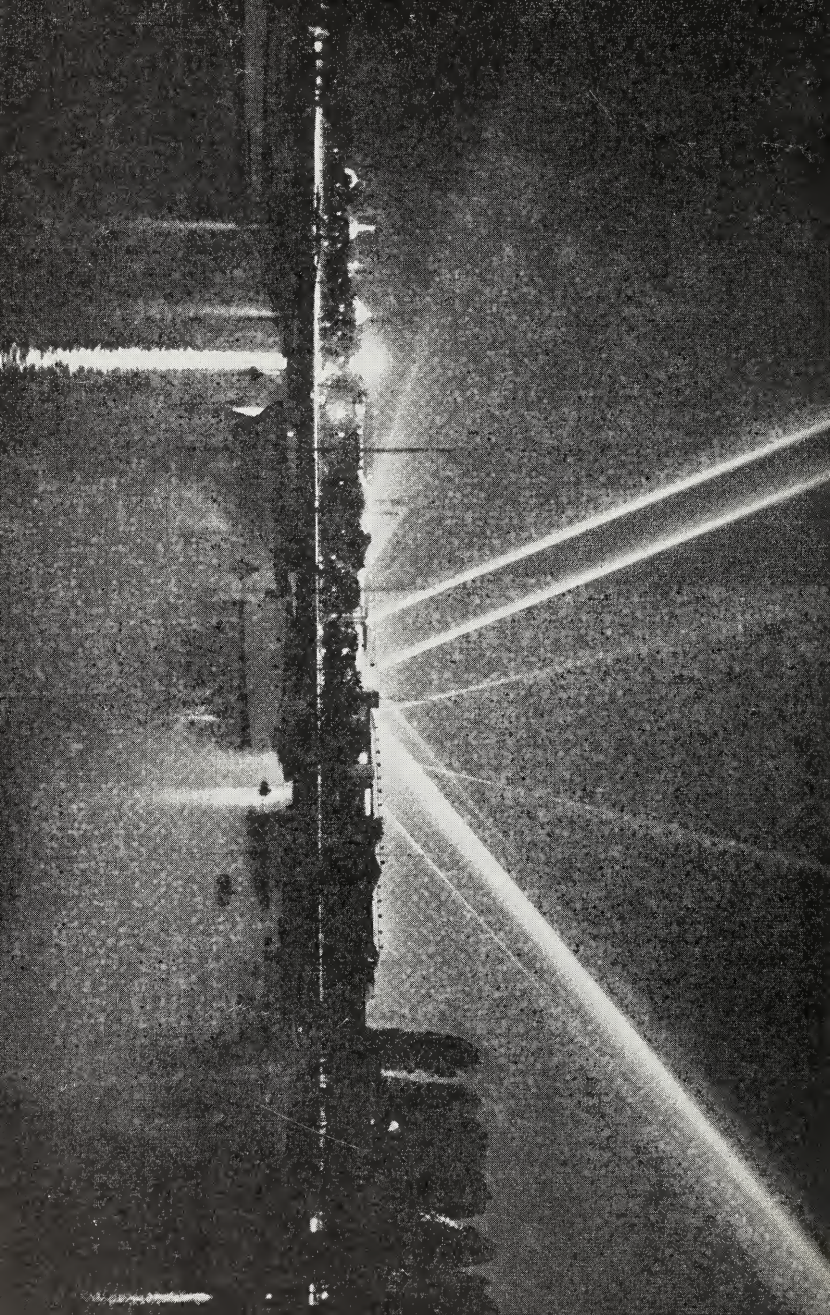
Film Strips

National Film Board of Canada

Fire Prevention (cartoon) (colour)

"Flashy" the Firebug (cartoon) (colour)

The Science of Fire Prevention



UNIT FIVE

Electricity in Modern Living

13. *HOW WE USE ELECTRICITY*

Electricity serves us in everyday living by providing us with heat, light, and power, and by helping us to communicate with our fellow men, far and near. Heat from electricity toasts our bread, irons and presses our clothes, and lights our homes, offices, and factories. Power from electricity operates machines and facilitates travel. Electricity, used in telephone, telegraph, radio, and television, keeps us in touch with the remainder of mankind. Unless handled safely, electricity, with its power to cause death and destruction, can become our master instead of our servant.

14. *HOW WE GET ELECTRICITY*

The electricity that reaches our lights and our electrical appliances through wires is usually far from its source. Most of it is produced by the power of falling water operating turbines and generators in a distant power station. Some of the electricity we use is produced by steam power, and some by chemical action in electric cells.

The picture on the opposite page shows how powerful searchlights, operated by electricity, illuminate the sky over the Canadian National Exhibition, Toronto, at night.

13

HOW WE USE ELECTRICITY

Electricity, carrier of light and power,
devourer of time and space, bearer
of human speech over land and sea,
greatest servant of man, itself unknown.

Inscribed on Union Station, Washington, D.C.

WHY CAN a twisted wire be made to toast our bread? How does the telephone enable us to talk to a friend across the continent? What causes the automobile to start when we step on the starter? Why does the room light up when we turn or push a switch? One word answers all these questions—electricity.

Electricity is a power that works for us in many ways. It lights our homes and streets. It drives our machines. It both cools our refrigerators and cooks our food. It cleans our rugs and ventilates our rooms. It connects us with distant friends and with the world around us by telephone and television, by radio and record player. Electricity is not mysterious; it is one of nature's forces which man has learned to control and use to his advantage. How grateful we should be to those who learned the secrets of electricity and invented the modern appliances by means of which we can use its power!

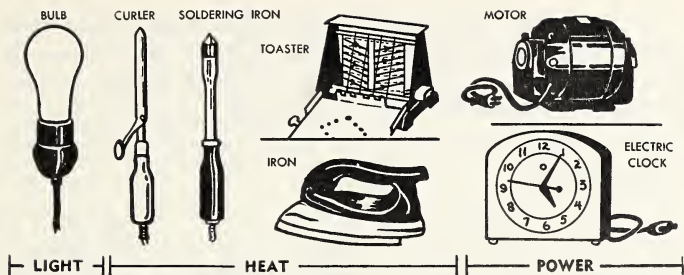


FIG. 13-1. SOME COMMON ELECTRICAL CONVENIENCES IN THE HOME.

Electricity has done much to improve the lot of farm people. Electric lights in modern farm homes and barns are safer and more convenient than the oil lamps and lanterns of earlier days. Electric irons and toasters, electric radios and refrigerators, electric washing machines and vacuum cleaners have provided more comfort, health, and leisure for farm women. By providing the power that operates milking machines, water pumps, and grain grinders, electricity has made the work of farmers easier and increased their efficiency.

Electricity Gives Us Heat

The electrical devices most familiar to us are those that produce heat. Most modern homes have some of these: irons, toasters, grills, water heaters, room heaters, coffee percolators, and heating pads. Even our electric light bulbs give us light only because the electricity passing through them produces heat.

A series of experiments with dry cells will show us how an electric current flowing through a wire produces heat.

EXPERIMENT 13-1. *Does a dry cell produce an electric current?*

Remove a little of the cloth and rubber covering from both ends of an electric wire a foot long. As in fig. 13-2,A, wrap one end of the wire around the central terminal of a dry cell and tighten the nut over it. Bring the other end near the outer terminal. What caused the spark?

The dry cell stores up electricity and gives it out when two terminals are connected by means of a wire. We say a current flows through the connecting wire.

When talking about electricity, we need to understand and use some special terms. Materials through which an electric current can flow freely are called *electrical conductors*. Among the best conductors of electricity are copper and silver. The electric wiring in our homes and in the cords of electric toasters and irons is copper.

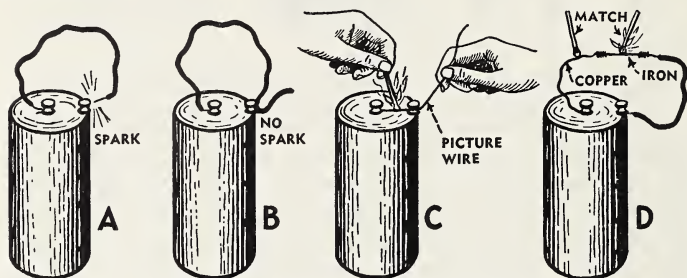


FIG. 13-2. EXPERIMENTS WITH DRY CELLS.

- A. A dry cell produces an electrical current, as shown by the spark.
- B. The current will not flow through the insulating cover of the wire.
- C. The electrical current produces heat, as shown by passing a current through a fine strand of iron picture wire.
- D. Iron wire offers more resistance to the current and, therefore, is heated more by it than copper wire is.

EXPERIMENT 13-2. *Are all substances electrical conductors?*

Connect an electric wire to the central terminal of a dry cell, then hold a covered part of the wire against the outer terminal (fig. 13-2,B). Can you get a spark? Why not? What prevented the current from passing from the wire to the terminal?

The rubber under the cloth cover of the electric wire prevented the electric current from flowing out of the copper wire to the terminal—somewhat as a rubber garden hose keeps the water flowing along through it, but not out of it. Just as a wooden knob on a kettle is called an insulator because it will not conduct much heat to the fingers, so materials that do not permit electricity to pass through them are called *electrical insulators*. Common substances that make good electrical insulators are rubber, glass, and porcelain.

PUPIL INVESTIGATIONS. *Look for electrical insulators.*

Search your home for porcelain sockets. Examine the electrical system of an automobile and find the porcelain insulators on the spark plugs. In both cases, the porcelain keeps the electric current from jumping out of the path we want it to follow.

We should be able to stop the flow of an electric current at will. We could do so by disconnecting the conducting wire, but we can do it more easily by pushing or turning the button of an electric switch. Inside the switch are two small metal plates, one joined to the incoming wire, and the other to the outgoing wire. When we turn off a switch, we separate the two metal plates, thus disconnecting the two wires and stopping the flow of the electric current.

PUPIL INVESTIGATION. *How does an electric switch work?*

Ask your father or an electrician to show you the inside of an electric switch. How does turning or pushing the button disconnect the electric wires?

If an electric current is to serve us well, we must be able to start it at will, guide it to the appliance we wish to use, and stop it when we want to. We produce a current by means of an electric battery or a generator; we direct its course by providing wires that are good conductors of electricity; we keep the current from going where we do not want it by means of electrical insulators; and we stop the current by disconnecting the conducting wire or by turning off a switch. All of these taken together—the source of the current, the conducting wires, the appliance operated, and the switch—make up what is called an *electrical circuit*.

EXPERIMENT 13-3. *Use your dry cell to produce heat.*

Remove a fine strand from a piece of picture wire. Attach one end of the strand to the central terminal of a dry cell. Holding the other end of the strand in the fingers, pull the strand tightly against the outside terminal (fig. 13-2,C). Notice the colour of the wire between the terminals. Touch the head of an unlighted match to the wire. Why does the match light? What effect has the current on the wire as it passes through it from one terminal to the other?

EXPERIMENT 13-4. *Which will make the better heating element, a piece of copper wire or a piece of iron wire?*

Connect a short piece of stove-pipe wire between two lengths of copper

wire, and complete the electrical circuit with a dry cell as shown in fig. 13-2,D. Touch the head of a match to the copper, then to the iron. Which is hotter?

Just as it is easier for you to run on land than in water, so it is easier for electricity to flow along a copper wire than along an iron wire. When you rub your hand forcibly against your coat sleeve, heat is produced because the sleeve resists the motion of your hand. In the same way, the iron wire resists the flow of the current more than the copper wire does, and so the iron wire becomes hotter.

EXPERIMENT 13-5. *Which will make the better heating element, a piece of fine wire or a piece of coarse wire?*

Repeat experiment 13-4. Replace the iron wire with a piece of very fine copper wire. Which becomes hotter, the coarse or the fine copper wire?

It is harder for you to squeeze through a small hole in a fence than through a big one. Similarly, it is harder for electricity to pass along a fine wire than along a coarse one. So the fine wire, offering more resistance, becomes hotter than the coarse wire.

PUPIL INVESTIGATIONS. *Find out how an electric heater is made.*

Follow the electric wiring on your toaster from the end of the cord into the toaster, then back and forth across the supporting frame until it returns to the cord. Notice how the mica insulators keep the loops of wire from touching each other or the frame. These insulators keep the current flowing through the full length of the element and ensure uniform toasting.

A heating element in an iron or a toaster should have two characteristics. It should be fine, and it should be of a metal through which a current flows with difficulty. Iron wire, if heated very hot in the presence of oxygen, soon burns out. Therefore, nichrome (made of iron, nickel, and chromium) is commonly used for elements in toasters and electric irons. The wire of the toaster element is coiled to give it greater length and, therefore, greater heating power. The element of an electric iron is usually like a thin ribbon. The flow of current through it may be stopped by means of a thermostat when the iron is hot enough. In electric space heaters, a spiral of nichrome wire is wrapped around an insulating porcelain cylinder.

Electricity Gives Us Light

In experiment 13-3 we found out that an electric current passing through a fine strand of wire heated it enough to light a match. If we had performed the experiment in the dark, we could have seen the wire become white-hot and glow, then give forth light.

Thomas Edison knew that an electric current could heat a wire until it glowed enough to give light. Aided by this knowledge, he succeeded in making the first electric light bulb nearly three-quarters of a century ago.

In his early teens, Thomas Edison worked by night as a telegraph operator at Stratford Junction, Ontario. He spent the days experimenting and inventing. Soon his main study was how to improve electric lighting for home use.

You probably found out that the fine iron wire that you used soon burned out when heated white-hot. Thomas Edison discovered this, too. He knew that if man was going to be able to use the light provided by a white-hot wire or filament, some way of heating the wire without having it burn must be found. Because he knew that the oxygen in air caused the wire to burn, he decided to enclose it in a glass bulb and pump all the air from the bulb. This helped to keep the wire from being burned. Edison tried many substances as filaments, and eventually he found that a bamboo fibre, treated with carbon and used in his air-free bulb, became glowing-white-hot and gave forth light without being burned. With this carbon filament he made the first electric light bulb. A wire is said to be incandescent when it is hot enough to glow. For this reason, electric bulbs using a wire filament are called *incandescent lamps*.

While Thomas Edison was experimenting with electricity as a means of providing light, other inventors were working on methods of improving the gas lamps then in popular use. To compete with the newly invented gas mantle, Edison searched for a metal that would glow more brightly than the carbon filament, yet not burn out. He discovered that tungsten would

do this. Further experiments showed that this wire lasted even longer when the bulbs were filled with nitrogen gas or argon gas after the air was removed.

PUPIL INVESTIGATIONS. *Examine carefully a modern incandescent lamp.*

Wrap a burned-out electric light bulb in cloth, then carefully break the glass. Find the small metal spot on the centre of the base of the bulb, also the metal screw at the side of the base. The electric current enters and leaves the bulb through these two metals. Trace the wires from these metals up through the stem into the glass bulb, then up to the filament. Notice that the fine tungsten filament is supported by an insulated loop of coarser wire in the centre of the bulb.

The finer the tungsten wire filament of an incandescent lamp, and the stronger the current flowing through it, the brighter the filament glows and the stronger the light produced.

Today we have other new types of electric light bulbs. The red electric signs on streets use neon lamps consisting of long tubes filled with neon gas. The neon gas in the tubes takes the place of a filament. The electric current passing through the gas causes the tubes to shine brightly.

The fluorescent bulb is a more recent invention. The bulb is shaped like a long glass tube and fits into an electric socket at each end. In the sockets, two prongs on the end of the bulb make contact with the two wires in the electrical circuit. In the tube, mercury and other substances glow brightly as the electric current passes through them. Because fluorescent bulbs use less electricity than incandescent bulbs to give the same amount of light, they are cheaper to operate.

Electricity Provides Power

When working with magnets, as we did when studying *General Science*, Book 1, we made a magnet out of a common four-inch nail. You will recall that all we had to do was wind some electric wire round and round the nail many times, then permit an electric current to flow through the wire. The nail then picked up tacks. Because the new magnet was made by electricity, we called it an electromagnet. Some electromagnets

are powerful enough to pick up huge pieces of scrap iron; others serve us in telephones, telegraphs, and electric motors. Electricity provides the power of electromagnets, and these provide the power used to operate many modern machines.

PUPIL INVESTIGATIONS. *How does electricity provide power?*

1. Make a list of appliances in which electricity is used to lighten man's work by providing power. Think of homes, barns, workshops and factories, dentists' offices, and transportation vehicles.

2. Find out how the electric current provides the power for one or two of the electrical appliances you have listed.

Doubtless your list includes vacuum cleaners, electric sewing machines, refrigerators, and elevators. Electricity enables all of these to work for us. To provide power, each piece of equipment must have an electric motor. This is a machine that can use the power of electricity to turn wheels or move things. You would enjoy making a toy electric motor.

EXPERIMENT 13-6. *Make a toy electric motor.*

For this experiment you will require a piece of board, a dry cell, four 4" nails, a large cork, a small glass vial, some sealing wax, thread, and about 60' of insulated electric wire. Use fig. 13-3 as a guide while you follow the directions below. Drive the three 4" nails, A, B, and C, into the board. Drive a similar nail horizontally through

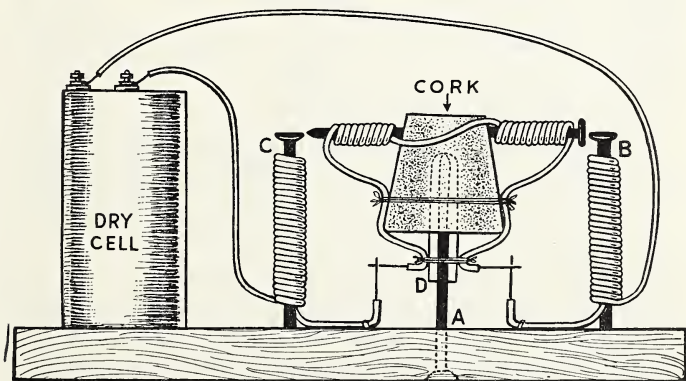


FIG. 13-3. A TOY ELECTRIC MOTOR.

the small end of the cork. Drill a hole in the centre of the large end of the cork; sink the base of the small glass vial, D, into this hole and fasten it there with sealing wax. Invert the glass vial, cork, and nail over the centre nail, A, and see that the equipment you have assembled can turn freely. Remove half an inch of insulation from the end of 20' of insulated electric wire, then wind the wire round and round the horizontal nail, always in the same direction, as shown. Use thread to tie the wire to the cork and to the vial, then bend out the bare ends of the wire. Now wrap each nail, B and C, with 20' of insulated wire, leaving one end of each wire long enough to be attached to the dry cell, and the other end long enough to be attached to the board as shown. Remove the insulation from all four ends of the wires. Bend up the free ends of the wires from the board so they just touch the ends of the wires bent out from the glass vial, both at the same time. Connect the other ends of the wires to the dry cell. If you have followed every direction carefully, the cork and everything attached to it should turn rapidly. You now have a working electric motor.

You have really been making electromagnets—and these have made the centre part of your motor turn. Each of the three electric coils became an electromagnet whenever a current passed through it. As these magnets acted on each other, they kept the centre coil turning round and round.

The electric motors that operate our household appliances and machines in our workshops work somewhat as your toy electric motor works.

PUPIL INVESTIGATIONS. *What are the main parts of an electric motor?*

Ask some adult to help you examine the electric motor that operates an electric sewing machine or a power saw — a motor that is not enclosed in the machine itself. Find the shaft that extends through the centre. Turn the shaft. If the end of the motor is open, look into it. Notice the many turns of wire on the shaft. These make up the *armature*. Look for other coils of wire inside the case surrounding the armature.

When the motor is connected in an electrical circuit, the current flows through the wire coils of the armature somewhat as it did through the coils on the outer nails in your toy electric motor. The current makes them electromagnets. At the same time, the coils in the surrounding case of the motor also become

electromagnets. As we learn more about electricity, we will discover that the armature and the shaft of an electric motor, like the central part of your toy electric motor, are turned rapidly by the magnetism caused by the electric current. As the shaft turns, it operates any machinery attached to it.

Electric motors serve us well. Their smallness makes them much more convenient than steam engines or gasoline motors. It is easier to conduct the electricity to an electric motor than to transport gasoline or other fuels to other kinds of motors. Electricity is cleaner, safer, and more economical than other sources of power.

Electricity in Communication

Man has always wanted to communicate with his fellow man. Electricity has done more than any other power to help him do so.

The Telegraph. Early man could transfer his thoughts to others only as far as his voice could carry. Gradually he learned other ways of sending messages to distant people (fig. 13-4).



FIG. 13-4. ANCIENT METHODS OF COMMUNICATION.

A, a tropical native signalling to tribesmen from his hollow stump drum; B, an ancient Greek reflecting signals with his shield, as you do with a mirror, in the sun; C, the carrier pigeon; D, Crusaders announcing their arrival; E, an Indian producing smoke signals with his blanket.

Only about a century ago, Samuel Morse discovered a means of using the newly discovered electricity to give us the telegraph.

Even then, each word of a message had to be spelled out in dots and dashes according to a code.

The Telephone. Then came Alexander Graham Bell. While experimenting at his home, now the Bell homestead, near Brantford, Ontario, he conceived the idea that the human voice, as well as dots and dashes, could be carried over wires by electricity. In 1874, seven years after the birth of our Dominion, while working with this idea, Bell spilled some acid and hurriedly called to his assistant: "Mr. Watson, please come here. I want you." This message, although it travelled only from his attic laboratory in Boston to the basement, was the first ever sent by telephone (*tele*-far; *phone*-sound).

The first long-distance talk in Canada occurred two years later. In 1878, telephone service started in Hamilton, where the first commercial telephone exchange in Canada was opened. Thirty-seven years later, in 1915, the same Mr. Bell spoke the original telephone message to the same Mr. Watson, this time from New York to San Francisco, 3,400 miles away. Now, you and I may speak our messages directly from our homes through telephone systems to people in every part of the world.

PUPIL INVESTIGATIONS. *Find out how a telephone works.*

1. While your teacher or your father works with you, remove the mouthpiece from an old telephone and examine the thin metal plate (diaphragm) just inside the opening. When you speak into the mouthpiece, your voice makes air move, then the moving air makes this diaphragm vibrate back and forth like the covering of a drum.

2. Unscrew the cap from a telephone receiver and remove the thin metal plate that lies inside. You will notice that this plate is held in place by a magnet, leaving it free to vibrate. You will also find two little electromagnets wound with fine wire. They work only when you are using the telephone. The voice at the other end of the line causes them to vibrate the metal plate back and forth and send air vibrations to your ear. These vibrations reproduce the sounds of the voice at the distant telephone.

Stop and think for a minute how marvellous and how important telephones are. They carry your voice across the whole of Canada in less time than it takes it to travel the length of

your classroom. Think of the complicated network of wires through the streets and buildings of a great city, enabling thousands of conversations to take place at the same time without interference with each other. How marvellous, too, that telephones, with the help of radio, make it possible to talk from ship to ship and from plane to plane! See fig. 13-5.

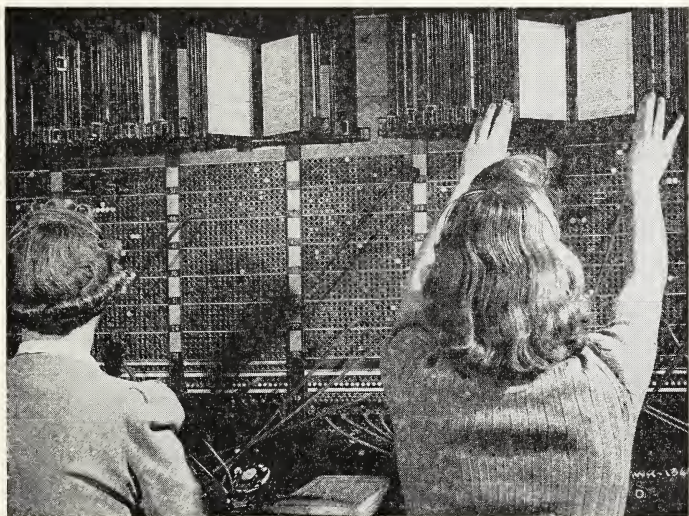


FIG. 13-5. A COMPLICATED AND BUSY TELEPHONE EXCHANGE.

The operators at this private branch exchange of the Government of Canada, at Ottawa, assisted by the directories overhead, handle more than 100,000 calls daily.

Radio. Little more than half a century ago, Marconi succeeded in sending a message two miles without using wires to carry an electric current. He had invented the radio, another gift of electricity. While we listen in the comfort of our living rooms to the voices of a choir in a concert hall three thousand miles away, we little realize that we hear each note before it has reached the people at the back of the concert hall.

How do the transmitted sounds reach us so naturally? The

microphone near the choir changes the sound waves of the singing to electrical waves. These electrical waves flow along wires to the control room, then to the transmitting station. Here, they are changed to radio waves and sent out from a tall antenna. Radio waves travel through air, earth, or brick. Tubes in our radio sets pick up the radio waves, strengthen them, and change them back to sound waves. From the speaker of the radio, these sound waves come to our ears as the sound of the distinct voices, unchanged. And to think that all these happenings require less



(From Compton's Pictured Encyclopedia)

FIG. 13-6. HOW COMMUNICATION HELPS PEOPLE THROUGHOUT THE WORLD TO LIVE TOGETHER.

With the help of electricity, radio and television bring the speaker's words to audiences in the world's most distant cities. Then newspapers and newsreels record and spread the message more widely.

time than it takes for the sound of the voices to reach a member of the audience itself!

Television. The genius of scientists and the marvels of electricity have combined to give us television, the seeing of things far away. By this invention, first demonstrated in 1926, we can actually see things on the screen of our television sets at the same time as they take place hundreds of miles away, and often as clearly as if we were there. Even the natural colours are reproduced by coloured television. Study fig. 13-6.

Television is much like radio combined with photography. A camera photographs an orchestra while a microphone picks up the sounds of the music. Both the sounds and the pictures are transmitted from the antenna of a transmitting station as electrical waves. The tube in the television receiving set picks up both kinds of electrical waves and changes them back to the sounds and the pictures of the orchestra. On the screen we see the orchestra in action as we hear its music.

We may wonder whether man can discover any greater marvels of electricity. Perhaps one of you will have that privilege in the years to come.

Safety in Using Electricity

Electricity is the servant of the modern world, but only when it is under control. It must be carried to where we want to use it by wires that conduct electricity easily and that do not become hot while doing so. These wires must also be well insulated to prevent contact with other objects.

Short Circuits. Electricity will take short cuts if it can. The insulating cover of the two adjoining wires of a toaster cord may become worn away and allow the two bared wires to touch each other (fig. 13-7). When the toaster is connected,

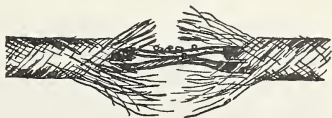


FIG. 13-7. FRAYED CORDS
CAUSE SHORT CIRCUITS.

Notice the little beads of melted copper where the bare wires touched and the current jumped across.

the electric current immediately takes a short cut at this point from one wire to the other, a *short circuit*, instead of taking the longer and more difficult course through the element of the toaster.

Two wires some distance apart may be short-circuited also by any good conductor of electricity that happens to join the metal of one to the metal of the other. For example, the body of a squirrel or of an electrician may accidentally short-circuit two "live" wires, with fatal results. A short circuit may be caused through the body of a person who touches a metal socket while standing on a moist floor or while handling a tap. Therefore, metal sockets should not be used near taps or in moist places.

Short circuits are caused also by defective electrical equipment, defective wiring, and accidental breaks in wires. When there is a short circuit, more electricity flows through the circuit. This increase in current may make the wires hot enough to set fire to any inflammable material they touch.

Short circuits are prevented by using well insulated wires, by repairing worn places in insulation, and by making all electrical connections carefully.

Worn insulation should be repaired by wrapping the wire with insulating tape. When connecting a wire to a terminal, the wire should be wrapped closely around the screw, which should be then fastened tightly (fig. 13-8). When connecting two electric wires, each wire should be wrapped securely around the other, then the joint soldered and wrapped with insulating electric tape.

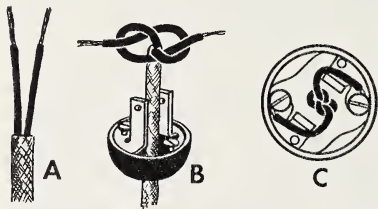


Fig. 13-8. How To Connect A Plug TO AN ELECTRIC WIRE.

Fuses. Fuses are used to prevent fires which may result from short circuits in electrical wiring. These fuses are contained in a fuse box, and electricity from the community electrical power system passes through them before it enters the wires, fixtures, appliances, and machines in buildings. In the fuse plug (fig. 13-9) is a short piece of metal, the fuse wire, through which the current must flow. When the current is too strong, this wire becomes hot and melts.

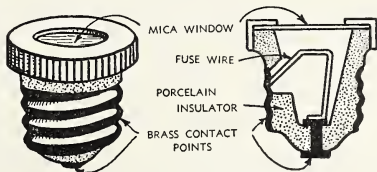


FIG. 13-9. A FUSE PLUG.
An outside and an inside view.

EXPERIMENT 13-7. *Find out how a fuse plug works.*

Connect a piece of tinfoil about $\frac{1}{8}$ " x 1" between two pieces of copper wire by means of paper clips. Connect the other ends of the copper wire with a dry cell. What happens to the tinfoil? The fuse wire in a fuse plug melts or burns out in the same manner when too strong a current flows through it.

When a short circuit occurs anywhere in an electrical circuit, the increased current will melt the fuse wire in a fuse, and this will break the circuit. When the circuit is broken, the current stops, and, perhaps, a fire is prevented. When the short circuit has been remedied, a new fuse must be screwed into the socket to replace the burned-out fuse. A burned-out fuse is easily recognized by the blackened mica covering its top. If the electric wires of the building are of a size meant to carry a current of only 15 amperes without becoming hot, then we must use a 15-ampere fuse so that the fuse wire will melt before the current exceeds this strength.

Safety Precautions. The human body, like a wire, conducts electricity. As the electric current passes through the body, it may destroy the nerves of the victim. If the nerves stop working, so will the muscles. If the shock is severe enough, the muscles controlling breathing are likely to be stopped, causing death. To be safe from these hazards connected with the use of electricity, we must be constantly on guard.

Safety precautions should be taken while a lamp, a toaster, a switch, or any other electrical equipment is being repaired. First, we should make sure that the appliance has been disconnected from the outlet. If this cannot be done, it is necessary to turn off the power at the meter box, or to remove a fuse. Otherwise, the body may short-circuit the ends of the two "live" wires with which we are working. In addition, it is wise to stand on rubber or some other insulating material when handling any electric wire or fixture from which a current could possibly pass. Of course, one should never touch any electric fixture when the hands are wet. Now study fig. 13-10 for other safety ideas.

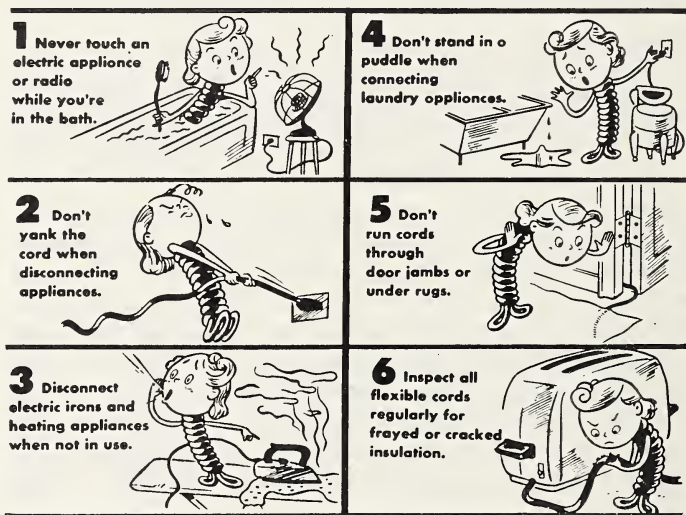


FIG. 13-10. DO'S AND DON'T'S WHEN HANDLING ELECTRICAL APPLIANCES.

Things To Do

1. Take a discarded electric iron apart and find out how electricity heats it.
2. Separate the parts of a light socket and discover how the current gets through it to the electric light bulb.
3. Compare a new fuse with one that has burned out.

4. Find out: (a) how a flashlight works; (b) how telephone connections are made in a telephone exchange; (c) what is in a dry cell; (d) where the electricity you use is generated and how it is transmitted to your home; (e) how a station telegrapher sends and receives messages; (f) how newspapers receive up-to-the-minute news.

Topics for Investigation and Report to the Class

1. Samuel Morse and the telegraph.
2. The invention of the telephone by Alexander Graham Bell.
3. How a telephone works.
4. The life and work of Marconi.
5. The contributions of Thomas A. Edison to the development of electric lights, the phonograph, and the radio.
6. The story of the first Atlantic cable.
7. How a radio programme is staged, sent out, transmitted to your home, and received by your radio.

Discuss These

1. How do the telephone and telegraph: (a) contribute to Canada's development, (b) help businessmen today?
2. Which helps us more to understand world affairs: the telephone, the telegraph, radio, or television?

Your Word List

Conductor, insulator, circuit (electrical), switch (electrical), fuse, generator, electromagnet.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "How Communication Helps Us Live Together", Vol. C, pp. 421-425; "How To Make a Telegraph Set", Vol. DE, p. 296; "Harnessing Electrons To Get Power, Light, and Heat", Vol. DE, pp. 309-314; "The Magic of Telephone Communication", Vol. TUV, pp. 39-45; "Seeing What Happens Everywhere by Television", Vol. TUV, pp. 50-55.

16 mm. Sound Films

Ontario Visual Education Branch

Home Electrical Appliances (VG-15)

Film Strip

National Film Board of Canada

Don't Be Shocked (colour)

14

HOW WE GET ELECTRICITY

ELECTRICITY SERVES US in many ways. We have discovered how it gives us heat and light, how it provides the power needed to operate our machines, and how it helps us to communicate with distant people. Let us see if we can discover how this servant of mankind may be produced and distributed.

Ways of Producing Electric Currents

When we think of electricity, we think of the great power that comes to us through wires. But these wires are only conductors being used to conduct electricity from its source to the places where it can be used. We should try to discover more about the sources of electricity.

Electricity Produced by Friction. That crackling sound you heard when you combed your hair, and the flash or spark you saw when you rubbed your hand over a cat's fur in the dark, were both signs of electricity. You can produce a similar charge of electricity by shuffling your shoes across a rug, then touching a radiator or another person.

EXPERIMENT 14-1. *A comb can produce electricity.*

Tear some paper into tiny pieces. Rub a comb (or a fountain pen) vigorously with woollen cloth. Bring the comb near the pieces of paper. What happens? Repeat the experiment several times.

The friction accompanying the rubbing produced electricity

on the comb. Like magnetism, the electricity attracted the paper, but it did not hold it long. This kind of electricity does not flow along a wire; it rests on an object, in this case, the comb. For this reason, it is called *static electricity*. This kind of electricity also causes the *static* we sometimes hear in a radio.

Electricity Produced by Chemical Action. We have been experimenting with dry cells. The electricity they give out is produced by the chemical action of substances in them. Other chemicals also may work together to produce electricity.

EXPERIMENT 14-2. Use a lemon to make electricity.

Thoroughly clean a strip of copper and one of zinc. Cut two slits in a lemon. Insert the strip of copper in one slit and the piece of zinc in the other (fig. 14-1,A). Join the other ends of the metal strips with your tongue or with electric wires leading to your tongue or to head phones. The tingling sensations that you feel in your tongue or the crackling noises heard through the head phones show that an electric current is passing between the metals.

EXPERIMENT 14-3. Make an electric cell.

Put a strong solution of salt or of ammonium chloride, or a dilute solution of sulphuric acid, in a tumbler. Immerse a piece of copper and a piece of zinc in the solution. Attach wires to the metals and bring the unattached ends of these wires to the opposite sides of your tongue or of a wet finger, or to an electric bell. Was an electric current produced? How do you know? Look for bubbles on the metals. See fig. 14-1,B.

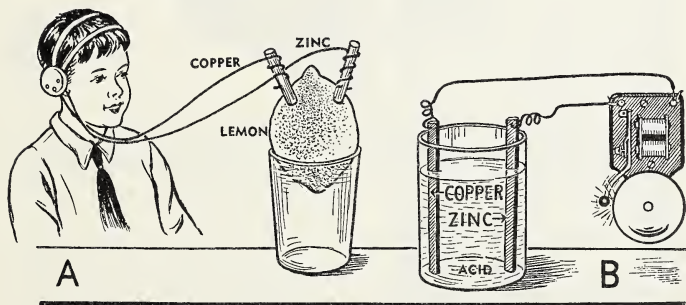


FIG. 14-1. CHEMICAL ACTION PRODUCES ELECTRICITY.

A. The acid juice in the lemon acts on the copper and zinc and produces electricity. B. In this electric cell dilute sulphuric acid acts on the copper and zinc to produce enough electricity to ring the electric bell.

The electric current produced when you experimented with the lemon and with the solution in the tumbler was caused by chemical action between the liquids and the two metals. The bubbles were the result of this chemical action.

Electricity Produced by a Storage Battery. When an automobile won't start, we think at once that the trouble may be in the battery. Because this battery stores electricity for the lights and starting motor, we call it a storage battery. The engine of an automobile provides enough power to keep the car going, operate the lights and such equipment as a radio and a heater, and generate some electricity to be stored in the battery. We say the engine charges the battery. This stored electricity can later start the car, operate the lights, or blow the horn. Fig. 14-2 shows how a storage battery works.

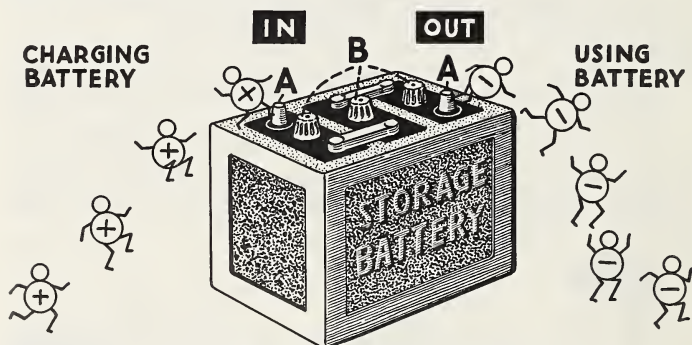


FIG. 14-2. HOW A STORAGE BATTERY WORKS.

A, the two terminals through which an electric current enters and leaves the battery; B, the caps covering the openings to the three cells of the battery.

Like the electric cell we have just made, the storage battery contains metallic plates and dilute sulphuric acid. As the generator of the automobile charges the battery, the acid becomes stronger. As the battery provides electricity for the lights or radio of the car, the acid solution becomes weaker, and the battery itself gradually becomes discharged.

Electricity Produced by a Generator. In the last chapter, we learned that an electric motor can do work when an electric current flows through it. The electricity causes the armature and the shaft in the motor to turn. A *generator* looks like an electric motor, and is similar to it in construction. Both contain an armature and a shaft in the centre. A motor, however, can work only when supplied with electricity, whereas a generator actually produces electricity when operated by some other power. The power of falling water, a steam engine, or a gasoline engine is used to turn the shaft and the armature of the generator. As the shaft and the armature turn rapidly, an electric current is produced. This current is then carried to wherever we wish to use it.

Electricity from Water Power

Falling water turned the mill wheels of the pioneers, enabling them to saw their logs or grind their grain into flour. Today this same power is used to produce the electricity that operates the machinery of our factories, drives our streetcars and electric railways, and lights our schools, offices, and homes.

Falling Water Has Power.

EXPERIMENT 14-4. *Falling water can turn a wheel.*

Make and use a water wheel, as shown in fig. 14-3,A. For blades, use the circular tops cut from vegetable tins. Nail them to the four sides of a block of wood about 2"

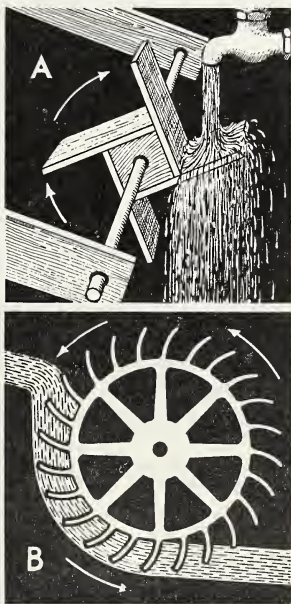


FIG. 14-3. WATER WHEELS.

A, a water wheel you can make and use; B, a "breast" type of water wheel, turned by a stream of water flowing part way around it and pressing on many of its blades at once.

square and 3" long. Bore a $\frac{1}{4}$ " hole lengthwise through the middle of the block. By means of a 4" nail put through the hole you have bored, fasten the block to a support as shown. Hold your paddle wheel in water falling from a tap.

Now study fig. 14-3,B and fig. 14-5 to learn how some other types of water wheels are turned by the power of water.

Let us consider why falling water can turn wheels. You know that a book or any object will fall to earth unless it is supported by something. The force that pulls it downwards is called *gravity*. Gravity acts on everything, including water.

Gravity causes a falling object to gain speed constantly while it continues to fall. The farther an object falls, the faster it travels. The faster an object falls, the harder it strikes the earth or any object in its path. This is true of falling water. The farther it has fallen, the faster it travels; the faster it is travelling, the more power it has to turn a water wheel.



FIG. 14-4. WATER "HEAD".

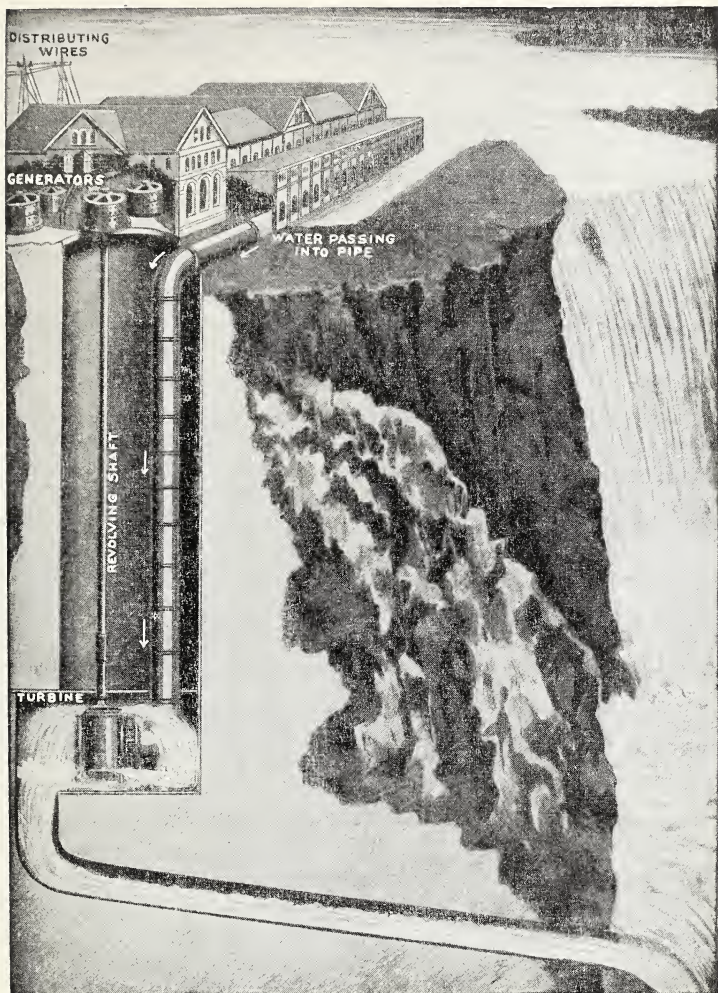
Notice that the four streams flow outwards different distances, showing that different pressures force them out. Read the text and explain why.

the water column is called the *head*. The greater the head, the greater the power of the falling water.

EXPERIMENT 14-5. *How does the depth of water affect its pressure or water power?*

In one side of a tall tin can punch four small holes of equal size, one above the other. Fill the can with water. Observe the shape of the streams from the holes. From which hole does the water shoot with the greatest force? Compare your observations with those illustrated in fig. 14-4.

The greater the height of the water column above the outlet, the greater the force with which the water flows out. The height of



(From Compton's Pictured Encyclopedia)

FIG. 14-5. HARNESSING THE POWER OF NIAGARA FALLS.

Some of the water from the river above the falls is directed into huge pipes, called penstocks. Through these, the water falls with tremendous force and turns the turbines at the bottom. Each turbine turns a shaft that operates an electrical generator in the power house above.

Water Power Can Be Changed to Electricity. The pioneers had to take their logs and their grain to the nearest sawmill or grist mill, always located beside a stream. Only there could the saws and the millstones be turned by the spinning water wheels. Since then, we have found a way to take the power of falling water to machines far away. This is done by changing the water power to electricity, then transmitting the electricity through wires to where we want to use it.

To change water power to electrical power, we use a type of water wheel called a *turbine*. Fig. 14-5 shows you how the falling water passes into a turbine through the sides, pushes against all the sloping blades at once, and spins the turbine. The water, having given up its power, then escapes through the bottom. The spinning turbine is fastened to a shaft which turns the working parts of the generator above. The generator changes this turning motion into electricity, ready to be carried by wires to wherever it is needed. Electrical power produced in this manner by the power of falling water is known as *hydro-electric power*.

Canada's Great Water-Power Resources. Most of Canada's hydro-electric power is produced in power plants beside natural waterfalls or by dams constructed to make artificial waterfalls. The higher the waterfall, the more electric power can be produced.

Ontario develops much of its electricity in power plants near Niagara Falls. The water of the Niagara River falls nearly 200 feet while flowing from the Upper Rapids to the foot of Niagara Falls. Much of the water used to generate electricity is carried in huge pipes (penstocks) from the top of the rapids to turbines in the power houses at the foot of the falls. The great power of the water that falls this long distance turns the turbines with such force that many thousands of horsepower of electricity are developed by the generators. Study fig. 14-5 again.

The water flowing from Lake Erie to Lake Ontario, through the Niagara River, falls a total distance of 326 feet. Most of this fall takes place as the water rushes from the rapids at Chippawa, down over Niagara Falls, and through the lower

rapids to Queenston. To make the most of the power of the water of the Niagara River, a huge canal was built across country from Chippawa to Queenston, known as the Queenston-Chippawa Power Canal. Through this canal the water flows to Queenston down a very gradual slope. At Queenston it falls nearly 300 feet through penstocks leading to the turbines at the bottom of the generating station. The power of the water falling so far enables ten generators to produce more than half a million horsepower. New tunnels from above Niagara Falls to a new generating station at Queenston have been constructed to harness much more of the mighty power of the water of the Niagara River and produce more hundreds of thousands of horsepower of electricity. Fig. 14-6 illustrates the two generating stations at Queenston.

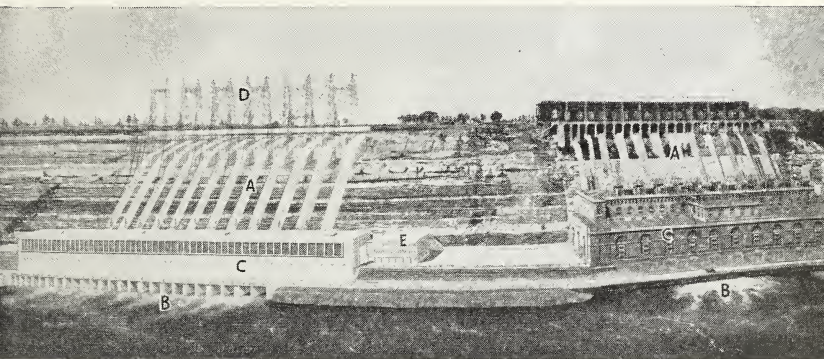


FIG. 14-6. TWO POWERFUL ONTARIO HYDRO GENERATING STATIONS SET IN THE 300-FOOT CLIFF OF THE NIAGARA GORGE.

At the right, the Sir Adam Beck-Niagara Generating Station No. 1 at Queenston, at one time the largest hydro-electric plant in the world.

At the left, an architect's drawing of the new Sir Adam Beck-Niagara Generating Station No. 2. Water to operate the turbines and generators is carried from above the Falls, through two tunnels under the city of Niagara Falls, then through an open-cut canal. The tunnels are so large that two 15-ton trucks could pass in them.

A, penstocks through which the water falls to the turbines; B, water escaping into Niagara River; C, the power houses containing the turbines and generators; D, a network of steel towers and transmission wires to carry away electricity; E, the control building for both stations.

Across some rivers it is necessary to build dams in order to produce artificial waterfalls and a head of water sufficient to generate electricity. Enormous dams and power plants along such rivers as the Ottawa, Trent, and Nipigon have greatly increased Ontario's supply of hydro-electric power.

Canada's inland waters provide her with one of the greatest water-power resources in the world. All provinces, except Prince Edward Island, develop large quantities of hydro-electric power. Quebec, Ontario, and British Columbia, in that order, lead in the production of electricity. Although less than one-fifth of the water power available in Canada has yet been harnessed, the power plants now in operation develop annually over 12,000,000 horsepower of electricity. This is equal to the power that could be produced by about 100,000,000 labourers. The power of the water in the rapids of the St. Lawrence River is almost unlimited. Brought under man's control, this unused source of power is capable of producing millions of horsepower of electricity.

Electricity from Steam Power

The sun that shone ages ago may light our homes or operate our machines by electricity. The green forests of those times stored up huge quantities of carbon which we find today embedded in the earth's crust in the form of coal. Using this, man makes steam and uses it to drive huge turbines, just as he uses water at Queenston. Even in Ontario, with its vast resources of water power, steam power is being used to drive generators and produce additional electricity.

Electricity from Atomic Energy

The atomic energy power plant at Des Joachims Generating Station on the Ottawa River is the first to be constructed in Canada to produce electricity.

Bringing Electricity to our Homes and Factories

Electricity can serve us only when it has been brought from the generators to where we wish to use it. Throughout the country may be seen huge steel towers with massive insulators and wide arms. These support the cables or transmission lines that carry

the high-voltage current from the power plants to the communities to be served. The high voltage of the current has to be reduced by passing it through transformers before it is safe for use in homes and factories. Large transformers to reduce the voltage may be placed at the entrance to a town, and smaller ones on posts near dwellings.

The company that supplies us with electricity is paid according to the strength of current we use, measured in kilowatts, and the number of hours during which current is being used. An electric meter measures both the current and the time, and indicates the number of kilowatt-hours for which we must pay.

Things To Do

1. Discuss the reason that the same amount of water from the Niagara River can produce more electricity at Queenston than at Niagara Falls.

2. Write to the Hydro-electric Power Commission of Ontario, at Toronto, for literature describing its power plants and its methods of distributing electricity throughout the province.

3. Write to the Water and Power Bureau, Department of Mines and Resources, Ottawa, for literature describing Canada's water-power resources.

4. Study an electric meter while it is measuring electricity being used. Find out how to read the meter.

5. Discuss in class the many ways in which Canada will benefit when the water power of the St. Lawrence River has all been harnessed to provide electricity.

Your Word List

Magnetism, static electricity, electric cell, storage battery, generator, gravity, water power, horsepower, turbine, transformer, insulator.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Three Ways To Make Electricity", Vol. DE, p. 295; "Harnessing Water To Help with the World's Work", Vol. WXYZ, pp. 67-70.

16 mm. Sound Films

Ontario Visual Education Branch

Making of Electricity (generators) (SG-50)

Ryerson Film Service, Toronto

The Principle of the Generator



UNIT SIX

Milk: the Most Nearly Complete Food

15. *MILK IS GOOD FOR YOU*

In Nature's plan, milk is the only food prepared especially to nourish the young of mammals, including humans. It supplies more of the needs of the body of adults, too, than any other single food. Its butterfat and milk sugar supply energy; its proteins build and repair body tissues; its minerals are essential for good teeth and strong bones; and its vitamins protect health. Milk has these values whether we take it as fresh milk, as condensed milk or other special forms of milk, or in such products of milk as butter and cheese.

16. *MILK, FROM GREEN PLANTS TO TABLE*

Milk is both nourishing and healthful only when it is produced by healthy cows, and when it is given proper care from dairy barn to table. Every precaution must be taken to keep milk clean and cold on the farm, while being transported to the dairy, in the dairy, during delivery to homes, and in our kitchens. Unless milk is pasteurized, it is not known to be free from disease-causing bacteria. Every precaution taken to maintain the good quality of milk is worth while.

15

MILK IS GOOD FOR YOU

MILK IS FIRST in importance among foods: it is “the most nearly complete food”. For the first few months of a child’s life, milk alone provides all the nourishment needed for the growth and warmth of the body, for energy to be active, and for general good health. Milk is the best, though not the only, food for growing children and youths. It meets more of the nutritional requirements of adults than any other food. Throughout our lives milk is the most commonly used food—as a beverage, on our breakfast cereals, in the preparation of custards and many other foods, and as the source of cream, butter, and cheese.

EVERYONE

NEEDS
MILK



BABY SISTER BROTHER MOTHER FATHER

FIG. 15-1.

Milk is the only food prepared by nature for the nourishment of young mammals—calves, lambs, colts, pigs, squirrels, puppies, kittens, whales, seals, and many others. It contains the food



MILK



TEEN-AGE
BOY

VITAMIN B ₂ (G) FROM OTHER FOODS $\frac{1}{3}$	CALCIUM FROM OTHER FOODS $\frac{1}{5}$	PROTEIN FROM OTHER FOODS
VITAMIN B ₂ (G) FROM MILK $\frac{2}{3}$	CALCIUM FROM MILK $\frac{4}{5}$	$\frac{2}{3}$
		PROTEIN FROM MILK $\frac{1}{3}$

ONE DAY'S NEEDS

FIG. 15-2.



ACTIVE
ADULT MAN

Three or four glasses of milk supply two-thirds of the vitamin B, four-fifths of the calcium, and one-third of the protein we need for a whole day.

elements needed for their health and growth, and it is easily digested. On the farm, milk makes up a large part of the food given to calves, pigs, and chickens. It promotes rapid growth when these animals are young.

Why Milk Is the Most Nearly Complete Food

Nutrients in Milk. When we studied from *General Science*, Book 1, we performed an experiment to find out what is in milk. The tests we are going to make now are quite similar, but your experience in doing experiments since then should help you to get better results. The table on page 264 will serve to guide you step by step in your method, to show you whether your observations have been correct, to help you to arrive at the right conclusions or explanations, and to serve as an example of how you might write reports on experiments.

EXPERIMENT 15-1. *Finding out what milk contains.*

Substances Found in Milk

What To Do	What You Should Observe	Conclusion or Explanation
1. Examine a drop of milk through a microscope.	Tiny, oily-looking drops floating in the milk.	These floating drops are globules of <i>butterfat</i> .
2. (a) Nearly fill a tall cylinder, graduate, or other tall, straight-sided container with milk. Allow it to stand a few hours. (b) Rub a drop of the cream on paper. (c) Measure the height of the column of milk, also the depth of the cream.	(a) The milk has separated into two distinct layers, cream on top and skim-milk below. (b) The cream forms a grease spot on the paper. (c) The cream may make up 1/10 or more of the milk.	(a) Cream rises to the top because it is lighter than the <i>skim-milk</i> below it. (b) The cream contains <i>butterfat</i> . (c) The cream may be half pure <i>butterfat</i> . The <i>butterfat</i> makes up 3% to 5% of the milk.
3. (a) Carefully pour off the cream. (b) Add a rennet tablet or a teaspoonful of vinegar to the skim-milk. Stir it. Leave it in a warm place for about two hours. (c) Strain off the curd.	(b) Curds form. (c) A thin liquid is left.	(a) The remainder is <i>skim-milk</i> . (b) The curds are <i>casein</i> , a <i>protein</i> in milk. <i>Casein</i> is the part of milk that is made into cheese. (c) The liquid is <i>whey</i> . It contains the <i>water</i> of milk.
4. Heat the whey.	A scum forms on it.	The scum is <i>albumin</i> , another protein in milk.
5. Skim off the albumin. Boil the clear liquid in a clean dish until dry. Taste the dry substance.	A solid substance is left in the dish. It tastes sweet.	The solid substance contains <i>milk sugar</i> . The water evaporated.
6. Continue to heat the solid for ten minutes, or burn it on mica.	Only an ash remains.	The ash contains <i>minerals</i> , chiefly <i>calcium</i> and <i>phosphorus</i> .

Our experiment shows us why milk ranks first among foods. We have learned previously that our bodies require five kinds of nutrients: carbohydrates, fats, proteins, minerals, and water, also vitamins. Milk supplies all of these. The milk sugar is a carbohydrate; butterfat is a fat; the casein and albumin are proteins; calcium and phosphorus are minerals essential to our bodies. Two vitamins necessary to health and growth are present in milk in large quantities, although our experiment did not show them.

Percentage Composition of Milk

Constituents	Average Amount*	How It Serves Our Bodies
Butterfat	3.8%	Fuel for body warmth and for energy of action
Milk Sugar	4.8%	Fuel for body warmth and for energy of action
Proteins	3.3%	For the building and repair of muscles and other body tissues
Minerals	.7%	Essential for good teeth and bones
Water	87.4%	
Vitamins		Promote growth and good health

*From *The Composition of Milks*, National Research Council, Washington, D.C., 1950.

Perhaps we will understand more readily the excellence of milk as a food if we think of the many ways in which it serves us as a food. If we are to remain warm and be active, our food must supply us with energy. The best energy-producing foods are fats and carbohydrates. Butterfat and milk sugar (a carbohydrate) are present in milk in such large quantities that they make milk our most economical energy-giving food. Milk contains from 3% to 5% butterfat, according to the breed of cow producing it, and nearly 5% milk sugar. The fat of milk is particularly valuable because it contains large amounts of Vitamin A.

MILK BUILDS BONES



GOOD BONES — GOOD POSTURE



STRONG FRAME — SMOOTH PERFORMANCE

FIG. 15-3.

Milk is a good food for the building of muscles and body tissues because it is rich in proteins. About 3.3% of milk is composed of casein and albumin. Of these, casein is the more important protein. Casein makes up most of the substance of cheese. A quart of milk supplies more than one-third of the total amount of protein required by an adult in a whole day.

Milk is an excellent food for the building of bones and teeth (fig. 15-3). Calcium is the chief mineral constituent of bones and teeth, and phosphorus is absolutely necessary for their development. Both minerals are present in excellent proportions in milk, and both are in an easily digested form. In fact, milk is our best source of calcium, in both quantity and quality. However, milk does not contain enough iron to meet all our needs.



**2 POUNDS
CHEDDAR
CHEESE**

**1 POUND
BUTTER**



**CONTAIN THE
PROTEIN, MINERALS,
FAT, AND VITAMIN A**

OF

**CONTAINS
ALL THE FAT
AND VITAMIN A**

10½ QUARTS



OF MILK

FIG. 15-4. BUTTER AND CHEESE ARE IMPORTANT FOODS.

Vitamins in Milk. Vitamins in our food are essential for the normal, healthy growth and development of the body. Milk has been described as the most important of all foods as a source of vitamin A, needed for the development of sound teeth and resistance to disease. Because vitamin A is found in butterfat, we obtain its benefits only when we use whole milk, cheese, or some product containing butterfat. Milk contains more vitamin A when the cows feed upon green grass.

Vitamin G is necessary for normal growth and health. Enough of this vitamin to serve a man's needs for a day is found in a quart of milk. Some vitamin C is found in raw milk, but part of it is destroyed by exposure to sunlight and by pasteurization. Although a small amount of vitamin D—the sunshine vitamin—is found in milk, the amount is not sufficient for the normal development of healthy bones and teeth without the help of sunshine, cod-liver oil, or some form of tablets or capsules containing vitamin D. In "irradiated milk" the amount of vitamin D present has been increased.

Safe and Palatable Milk

What a pity that such an excellent food as milk spoils so easily, or is so often actually dangerous! Milk that looks and tastes good to us may be the carrier of dangerous bacteria. Bacteria that cause undulant fever or tuberculosis may have come from a sick cow. Those that cause typhoid fever or septic sore throat may have entered the milk from milk utensils or from people handling milk. Unfortunately, milk is as good a food for these bacteria as it is for us. In it, they multiply rapidly, becoming so numerous that the milk is too dangerous for use.

Prevention is better than cure. In the next chapter we shall learn the steps that may be taken to make certain that only safe milk is produced on dairy farms, and how this milk may be kept safe until it is used.

Milk that was once good and safe for food may become spoiled by souring. This change also is caused by bacteria, called lactic acid bacteria, when they multiply in milk. We learned in

chapter 4 that bacteria multiply rapidly when given good food and warmth. We cannot remove from milk the food required by bacteria, for we require this food ourselves, but we can keep milk so cold that bacteria will not be able to grow and multiply in it. In this way we keep milk from spoiling.

Milk in Our Diet

Milk serves us best when used with other foods. It is not a perfect food when taken alone, chiefly because some of the food elements in it are not present in just the right proportions to nourish our bodies adequately. Everyone, except infants, requires more iron than milk can supply. Vegetables help to supply this deficiency. Milk does not provide enough vitamin D or vitamin C to serve our daily needs. Therefore, we must get vitamin D and vitamin C from other sources. Only infants would obtain sufficient fat and carbohydrate from milk without other foods. For these reasons, children are fed some foods other than milk at an early age. Milk nourishes us just as well when it is served in soups or puddings, or in creamed meats and vegetables, as when it is taken as a beverage or on breakfast cereals.

Milk is used in many ways in our usual three meals a day. In some forms, it is still called milk; in others, it has been manufactured into new products.

Special Forms of Milk. Milk is marketed under many different names, each form serving a special purpose. Most large dairies have installed machinery to break up the fat globules of milk so finely that they remain uniformly mixed throughout the milk instead of coming to the top as cream. This *homogenized milk* tastes richer, and is thought to make smoother custards and cream soups. In many modern dairies the amount of vitamin D is increased as the milk flows in a thin film exposed to ultraviolet rays given off by a special kind of electric lamp. This milk is called *irradiated milk*.

In order that milk may be more easily preserved and transported, it is often made into evaporated milk, condensed milk, or milk powder. *Evaporated milk* is made by heating milk until about 60 per cent of the water in it evaporates. It is then sealed in cans and sterilized. *Condensed milk* is sweetened evaporated milk. Both evaporated and condensed milk may be used for general household purposes. After the cans have been opened, these forms of milk require the same care as fresh milk. *Dried milk* is milk from which enough water has been removed to leave only a dry powder. Whole milk, skim-milk, and buttermilk may be dried. Powdered forms of milk are convenient to use in bakeries and to feed stock. *Chocolate Flavoured Dairy Milk* is the correct name for the milk drink made by adding sugar, cocoa, salt, and flavouring to milk.

Some Products of Milk. Butter, cheese, and ice cream are our most popular dairy products. We like them because they appeal to the taste; we are nourished well by them because they contain so many of the same food values as milk.

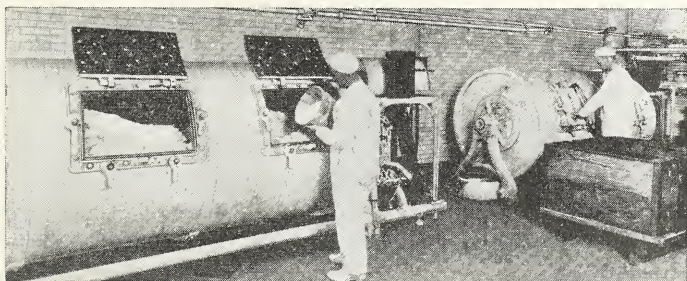


FIG. 15-5. MAKING AND PACKING BUTTER.

In this creamery we see freshly churned butter being salted and taken from the churns, ready to be packed in boxes.

Next to milk, butter is second in importance among dairy products. Because it consists chiefly of the fat of milk, it is both an excellent energy-giving food and our best source of vitamin A. To remain palatable, butter must be kept cool and away from strong odours. Cheese has been a favourite food for centuries.

A pound of ordinary Cheddar cheese contains most of the proteins and a large proportion of the fat and calcium of ten pounds of milk. In fact, a pound of Cheddar cheese provides nearly as much nourishment as two pounds of meat.

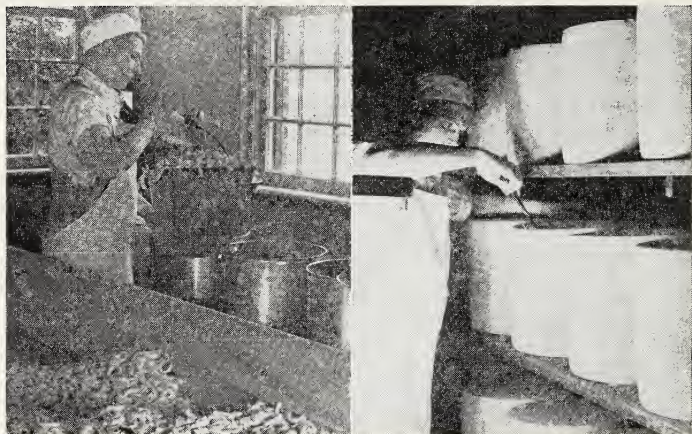


FIG. 15-6. TWO STEPS IN MAKING CHEESE.

A, curd being taken from the vat and placed in containers, ready to be pressed to form cheese; B, cheese in a store-room ripening for market, each cheese labelled according to government regulations to indicate the date of its manufacture and the factory in which it was made.

Ice cream is an easily digested, nutritious, and wholesome food. It consists chiefly of milk and cream, combined with sugar, gelatin, egg products, and flavourings. The milk in ice cream contains fat, proteins, and milk sugar, also the two important minerals, calcium and phosphorus. The other food materials added to the milk increase the food value and improve the taste of ice cream.

Skim-milk and buttermilk are both good foods. Skim-milk, often called separated milk, is whole milk from which most of the cream has been separated. Therefore, skim-milk contains a large proportion of the proteins, sugar, and minerals of whole milk. The lack of fat in skim-milk makes it less valuable than whole milk as an energy-giving food and as a source of vitamin A. For those who do not require fats, skim-milk is an abundant

and a cheap source of protein, calcium, and vitamin G. Butter-milk is a well-known product of milk. It is the residue left after the butterfat of cream has been removed in the making of butter. Buttermilk is used in baking and is a healthful beverage, largely because it is easily digested. It is also a cheap source of protein.

Milk in Canada's Wealth

1. The average Canadian consumes 475 quarts of milk per year in one form or another: as fresh milk; as butter, from the milkman and the corner store; as cheese, in most refrigerated counters; and as ice cream, available from dairy bars and drug stores.

2. Milk and its products supply one-third of all the food nutrients consumed by Canadians, at a total cost of only 20 per cent of the money spent on all food.

3. Dairying and the industries depending upon milk and milk products give employment to more than 2,000,000 Canadians. Some of these are employed on dairy farms, in creameries, and in cheese factories; others work in factories that supply dairy machines and utensils, equipment for the transportation of milk, and machinery used on dairy farms.

A Review

1. Make a table somewhat like the one suggested below. Fill in the details after reviewing the information given in this chapter and finding new information to supplement it.

Milk as Food

	Kinds	Useful Purposes Served by Each
Food Elements in Milk	1. 2.	
Proteins	1.	
Carbo- hydrates	2.	
Minerals	1. 2.	
Vitamins in Milk	Vitamin A Vitamin G (B2)	
Milk Products	Butter Cheese etc.	

For Investigation

1. Ask a grocer to show you a package of each kind of cheese he sells. Make a note of the name, source, weight, and price of each kind. Work out the price per pound. Try to find out how each kind of cheese is made.

2. Visit a cheese factory, or a creamery where butter is made. Find out: how milk or cream is brought in, tested, and weighed; how milk or cream cans are cleaned; the stages in the manufacture of cheese or butter; how cheese or butter are stored before being shipped; and where these dairy products are sold.

3. Write to the Associated Milk Foundations, 86 Charles St. E., Toronto 5, for a list of educational materials that may be obtained free or at nominal prices.

Answer These

1. Why is milk called the most nearly complete food?

2. What part of milk (a) provides energy, (b) gives bone-building material, (c) builds muscle and flesh, (d) helps to protect us from disease?

3. What is: condensed milk, evaporated milk, milk powder, butter-fat, skim-milk? Compare each in food value with fresh milk.

Your Word List

Nourishment, nutrients, butterfat, casein, albumin, calcium, phosphorus, proteins, carbohydrates, constituents, vitamin, palatable, evaporated, condensed, skim-milk.

Read

Compton's Pictured Encyclopedia, 1953 Edition

"Milk and Its Products—Our Basic Foods", Vol. M, pp. 250-253.

16 mm. Sound Film

National Film Board

Milk-made (colour)

Film Strip

National Film Board

Why We Eat—Milk (colour)

16

MILK, FROM GREEN PLANT TO TABLE

THE STORY OF MILK and milk products does not begin with the cow, as we might think. It begins earlier. To produce milk, the cow must feed upon grass, hay, grain, and other products of the soil. The growth of the green plants depends upon minerals in the soil, carbon dioxide in the air, and energy from the sun. The amount of calcium and other health-giving minerals in milk is determined by the amount of these in the soil where the grass and other cattle feeds are grown. All of these, good soil for pasture grasses, good hay and grain, and good cows, coupled with the planning and labour of the dairy farmer, enter into the production of healthful milk and nourishing milk products.

Producing Healthful Milk

The quality of the milk leaving the farm determines the quality of the bottled milk, cream, butter, or cheese made from it. The dairy farmer, therefore, holds the key to good dairy products.

High-quality milk is free from dirt particles, harmful germs, and unpleasant odours and flavours. The dairy farmer's task in

producing the finest milk is four-fold. He must be sure that all the cows in his herd are healthy. He must feed his cows only feeds that make good-flavoured milk. He must see that the milk is kept free of impurities during and after milking. And he must constantly keep the milk cool enough to prevent any bacteria in it from multiplying. The dairy farmer who fulfills these requirements will send only high-quality milk to market.

PUPIL INVESTIGATIONS. *A survey of dairying in your community.*

Find out: which farmers in the community produce more milk than is needed for home use; which breeds of dairy cows are most popular, and why; what each farmer does with his surplus milk; where the nearest dairy, creamery, and cheese factory are; how milk is transported from the farms; what equipment farmers use to cool their milk.

Healthy Cows for Safe Milk. Harmful bacteria and undesirable taints may be in the milk when it comes from the cow. Tuberculosis is the most common and most serious disease of cattle that can make their milk dangerous. Because a cow may be diseased a long time before the farmer knows it, she may infect several other cows, and their milk may carry the bacteria of this disease to those who drink it. In Ontario, as in most provinces, farmers who ship milk to dairies are required by law to have their cows tuberculin-tested annually to discover whether they have the disease. All diseased animals are destroyed, and the stables are disinfected.

Selection and Care of Dairy Cows. An adequate supply of high-quality milk depends upon the selection and care of the dairy herd. The quantity and richness of milk are determined by the breed of cow producing it, and by the feed given the cows; its safeness and purity are limited by the health of the cows, the cleanliness of their surroundings, and the facilities for the handling of the milk.

The best breeds of dairy cattle that provide the milk for most of our dairy products are the Holstein-Friesian, the Ayrshire, the Guernsey, and the Jersey (fig. 23-3). These breeds have been developed by centuries of careful breeding, and they are still

constantly being improved. The quality and quantity of their milk adequately repay the farmer for his investment in them and in their care and feeding. Most dairy herds are raised on up-to-date dairy farms within reasonable shipping distance of large urban centres or of milk processing factories.

To safeguard the health of the cows and the purity of the milk, the dairy stable should be carefully planned. It should be so constructed that good ventilation is provided for, and direct sunlight reaches as much of the interior as possible. To make cleaning easy, both the feed troughs and the floor should be of smooth concrete. The stalls and partitions, preferably of steel, should be kept painted, and the walls and ceiling whitewashed. To make available the large amount of water needed by cows for milk production—an average of 8 gallons for each cow per day—the dairy stable should have a water bowl, always filled, in front of each cow. Now study fig. 16-1,B.

For summer feeding, cows should have plentiful pasture, shade, and pure water (fig. 16-1,A). For winter feed, most farms produce hay and grain, ensilage, and perhaps fodder corn and root crops. Ensilage is made by cutting fine such green crops as corn; then it is blown into a silo. Here, the ensilage ferments just enough to remain juicy and nourishing. Fodder corn is dried in the field, then fed like hay. Because these feeds produced on the farm may not contain enough protein, calcium, and phosphorus to produce the most nourishing milk, dairy farmers often buy bran and oil cake as additional feed. Common salt is kept available to cows at all times.

When properly housed and well fed, the dairy cow becomes an important food factory. She excels in changing coarse plant materials into nourishing milk. She keeps on feeding until she is no longer hungry, but chews her food merely enough to swallow it easily. Then, usually while lying down, she brings the food, a little at a time, back to her mouth, and “chews her cud”. For nearly a third of her time the dairy cow is thus grinding feed and digesting it. Much of the nourishment absorbed by her blood stream is needed to make milk.

Proper Care of Milk on the Farm. When milk comes from healthy cows, properly cared for, it is usually pure. It is easy, however, for both filth and bacteria to enter the milk at milking time unless the strictest care is taken to ensure cleanliness. Milk may be contaminated by dust or odours in the air, by hairs or other impurities falling from the cow, by unclean dairy utensils, or by the milker himself.

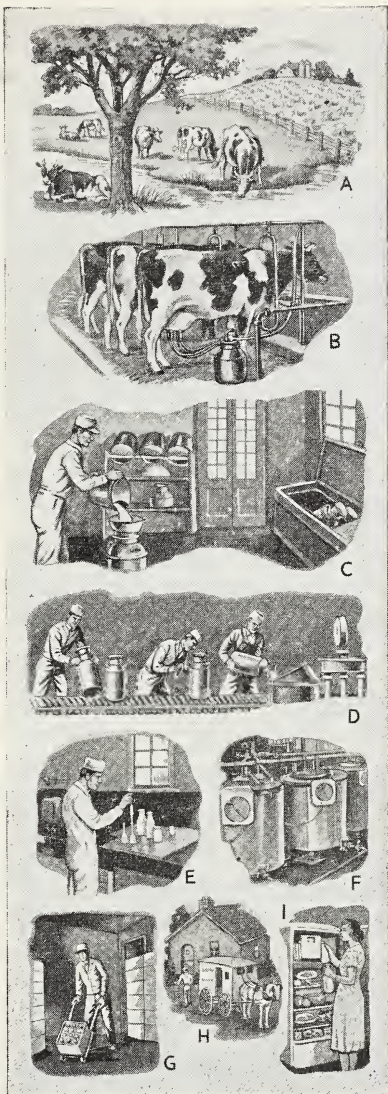
Milk is less likely to be contaminated by dust in the air if the cows are fed their hay or other dry feeds early enough to allow all dust to have settled before the cows are milked. At milking time, the stable should be clean and free from strong odours such as those of turnips or ensilage. To prevent impurities from falling from the cows into the milk, the flanks of the cows should be clipped frequently and both the flanks and the udders washed free of dust and other impurities before each milking. Milk pails with partly covered tops catch less dirt than those with open tops. Milking machines are even more sanitary because the milk passes through hoses from the cow's udder to closed containers and at no time comes into contact with the stable air or the milker (fig. 16-1,B). To avoid further contamination, milk should be taken from the stable as soon as possible after being drawn from the cows.

Milk pails and other milk utensils are frequently a source of impurities unless great care is taken in washing and sterilizing them. It is unwise to use pails with open seams or crevices because these openings hold such impurities as bacteria, dust, and stale milk particles even after being washed. All utensils should be rinsed in cold or lukewarm water immediately after use, then brushed well with a warm solution of washing soda or other washing powder, and rinsed with hot water. After being scalded or sterilized with steam, the utensils should be left to dry, upside down on a sheltered rack and, preferably, in the sun. If a milking machine is used, all parts of it that come in contact with milk should be cleansed as thoroughly as are other milk utensils. Dairies take precautions similar to those described above in order to return all milk cans to the farmer free from dirt and bacteria.

The contamination of milk by the milker must be prevented. His clothing should be light in colour to show soiling readily, and should be washed frequently. His hands should be clean and dry, and, of course, he should be free from communicable diseases. Milk may be infected by bacteria of typhoid fever, scarlet fever, tuberculosis, diphtheria, or septic sore

FIG. 16-1. MILK, FROM FARM TO CITY HOME.

A. In summer, dairy cattle require shade, pure water, and nutritious grass grown on soil that supplies adequate amounts of calcium, phosphorus, and other health-giving minerals. B. Holstein cows being milked by a milking machine. Notice the water bowl, the steel equipment, and the cleanliness of the surroundings. C. The milk is strained and immediately cooled in a cooling tank in a clean, bright milkhouse. Notice the covered milk pails. D. At the dairy, the milk is inspected and weighed. E. Milk being tested for butterfat content. F. Modern pasteurizing tanks. G. Bottled milk stored in a refrigerated room. H. The milk on its way to homes. I. The milk is kept clean, cold, and covered in the refrigerator.



throat. These bacteria may come from those who handle the milk, whether they have the disease or merely carry the germs. Serious epidemics have resulted from such infection of milk that was not later pasteurized.

Good milk can be kept good only by proper methods of storage on the farm after milking. The cleanest of milk contains some bacteria. Experiments have shown that one germ in milk at 50°F . may increase to five germs in 24 hours, but that one germ in milk at 68°F . produces more than 6,000 germs in the same length of time. As the germs increase in number, the quality of the milk is lowered even if it has not yet soured. To keep whatever bacteria may be in milk from multiplying rapidly, the milk must be cooled to 50°F . or lower as soon as it is taken from the cows. If it is to remain sweet for a reasonable length of time, it must be kept at this low temperature. The usual method is to lower the milk or cream cans into a well or spring, or into a concrete tank containing water kept cold by ice or refrigeration. Study fig. 16-1,C.

A milkhouse is convenient for safe storage of milk on the farm. In this building are kept the cooling tank, the cream separator (if one is used), and other dairy utensils. It is important that the milkhouse be clean, well ventilated, and screened to keep out flies, and that its windows let in direct sunlight. See fig. 16-1,C.

Keeping Milk Healthful from Farm to Consumer

Precautions to keep milk safe and palatable must be continued after the milk is taken from the dairy farm. To take these precautions is the responsibility of the dairy that sells fresh milk or of the manufacturer of milk products.

Transporting Milk to the Dairy or the Manufacturer. In the horse-and-buggy days milk was seldom transported very far. As cities have grown larger, the areas from which milk must be collected have also enlarged. Now milk is often transported a distance of a hundred miles—and that, every day of the year. To

keep the milk in good condition during its journey, modern methods of transportation are needed. Milk can be taken long distances in railway or truck tanks. These tanks are insulated, and sometimes refrigerated, to keep the milk cool on the way to the dairy (fig. 16-2).

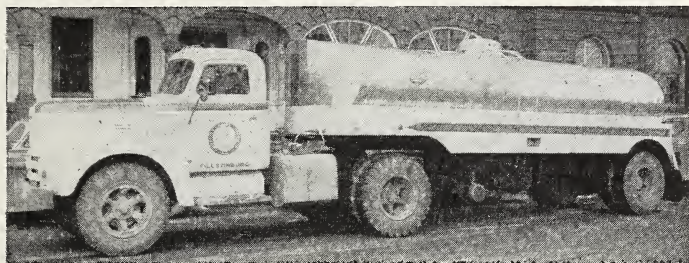


FIG. 16-2. A MODERN TRUCK TANK.

This is constructed to keep milk clean and cool on its way from the dairy farm to the dairy or the processing factory.

The Care of Milk by the Dairy.

PUPIL INVESTIGATIONS.

1. Visit a dairy to see how milk is brought in, tested, weighed pasteurized, cooled, bottled, and stored. See what precautions are taken at each stage to keep the milk pure.
2. Write to your Provincial Department of Health for a copy of the regulations concerning milk.

Receiving and Testing Milk. The dairy farmer is paid for his milk according to its weight, quality, and richness in butterfat. At the dairy, the milk from each farm is tested for flavour and sweetness by smelling it, and its weight is recorded (fig. 16-1,D). A sample of the milk supplied by each farmer is taken daily. This is added to samples taken on previous days and kept in storage. Each two weeks or so the combined samples are tested by means of the Babcock butterfat test to discover the average percentage of butterfat contained in the milk. This information is recorded and used to determine the amount to be paid to the farmer for the milk he has supplied to the dairy.

After the milk has been tested and weighed, and a sample taken from it, it is emptied into large storage tanks. In these it is kept constantly at a temperature below 50°F .

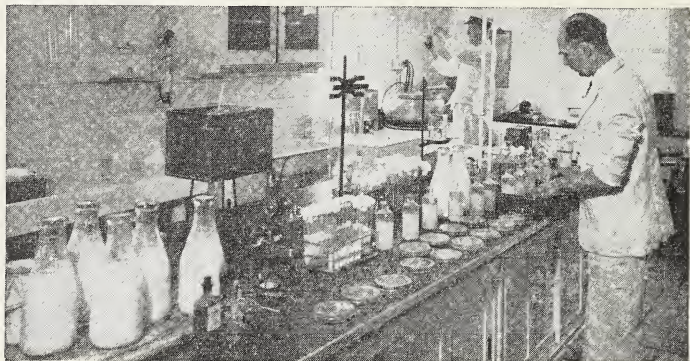


FIG. 16-3. THE LABORATORY OF A MODERN DAIRY.

Specialists in dairy science here perform many kinds of experiments and tests to make certain that milk delivered to our homes is as pure, wholesome, and nourishing as possible.

Pasteurizing Milk. Milk that is unsafe when it reaches the dairy may be made safe by *pasteurization*. This process consists of heating the milk sufficiently to kill any harmful bacteria that may be present, especially those of tuberculosis, typhoid fever, and septic sore throat.

EXPERIMENT 16-1. *Pasteurize some milk and compare its keeping qualities with those of raw milk.*

Put half a pint of raw milk into each of two sterilized bottles and plug the neck of each with sterile cotton.

Heat the milk in one bottle to a temperature of 143°F . to 145°F . by placing the bottle in a water bath on a stove or heater. Keep the milk at this pasteurizing temperature for 30 minutes. The temperature may be read from a thermometer placed in a bottle of water beside the milk. After pasteurization, cool the milk by putting the bottle containing it into cold water.

Keep both the raw and the pasteurized milk in a place at about classroom temperature for a few days. Test the milk in each bottle for flavour and odour each morning and late afternoon. In which bottle does the milk spoil or sour first? Try to explain why.

In dairies, the milk flows from the large storage tanks into special pasteurizing tanks (fig. 16-1,F). On its way, it passes through a system of filters which remove any particles of dirt. In the pasteurizing tanks, the milk is heated to a temperature of 143°F . and kept at this temperature for 30 minutes. During this process, the milk is in constant circulation so that all of it is heated to the same temperature. In some modern dairies, the milk is pasteurized by heating it to a temperature of 161°F ., but for only 16 seconds. When pasteurization is complete, the milk is immediately cooled to a temperature of 50°F . Then it is ready for bottling.

To review what you have read, study fig. 16-4.

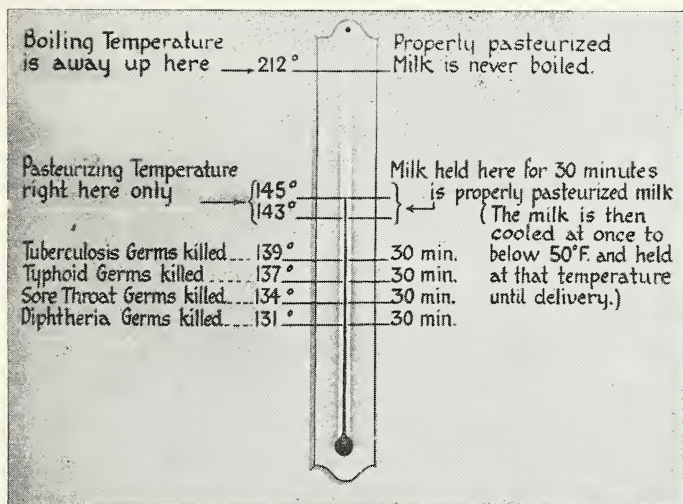


FIG. 16-4. PASTEURIZATION MEANS PRECAUTION, PROTECTION, AND PREVENTION.

When properly carried out, pasteurization does not change the flavour or the food value of milk. It does make milk free from harmful bacteria and, therefore, a perfectly safe food. Because pasteurization checks the increase of those bacteria that cause milk to sour, pasteurized milk stays sweet longer

than raw milk. For these reasons, we should be grateful to the famous French scientist, Louis Pasteur, for whom pasteurization has been named, for proving that germs can be killed by heat.

In Ontario and Saskatchewan it is illegal to sell or to deliver unpasteurized milk in a city or town, except to a dairy. This applies to all milk products other than butter or cheese. In Ontario the Provincial Health Department enforces this law through its representatives, the Medical Officers of Health, in order to protect citizens from diseases caused by bacteria in raw milk. To make pasteurization more effective, the Department of Health has regulations also concerning buildings, water supply, utensils, bottling, and the health of dairy employees.

Bottling Milk. The bottles returned to the dairy are unloaded onto a conveyor or moving track which carries them to a washing machine. After successive washing treatments, each bottle moves along on another conveyor to a bottle-filler. Here it is mechanically filled and capped without human hands touching the milk (fig. 16-5). After inspection, the bottles of milk are crated, rinsed, and stored in a refrigerated room at a temperature just above freezing point until time for delivery. See fig. 16-1,G.

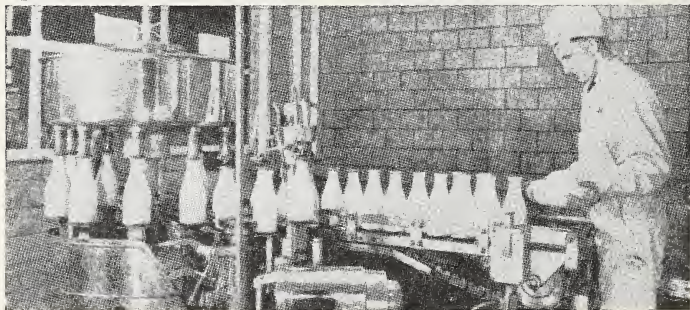


FIG. 16-5. BOTTLING MILK.

As each clean, sterilized, cool bottle moves from a bottle-washing machine around the bottling machine and under a filling spout, air is drawn from it by suction and the correct amount of milk enters it. When the bottle has been sealed with a paper cap (from the white tubes), it moves along the conveyor for inspection and storage in a refrigerated room.

In an up-to-date dairy, as well as on a good dairy farm, constant care is taken to insure that the milk is always in clean, healthful surroundings. All equipment coming in contact with milk is taken apart and thoroughly cleansed and sterilized. The walls and floors of the dairy are washed every day, and the workmen wear clean, white uniforms.

Delivering Milk from Dairy to Home. In summer, the milkman usually loads the milk, cream, and butter from storage onto his delivery waggon or truck not long after midnight—a precaution against exposing such perishable foods to more heat than is necessary. Every possible precaution is taken by the dairy to keep milk and milk products clean and cool until they are placed in the consumers' milk boxes.

Caring for Milk in the Home. The key words in describing the care of milk in the home are *clean, cold, and covered*. A milk box or other protected place should be provided to receive the milk delivered to the home. The milk should be brought in at once to prevent freezing in winter and heating in summer. After the tops have been wiped with a clean, damp cloth, the bottles should be placed in the coldest part of the refrigerator or in some other cold place free from odours (fig. 16-1,I). Only the milk that is required for immediate use should be taken from the bottle. The old bottle top should be destroyed when removed, and a clean glass inverted over the bottle. Milk should be protected from strong light to preserve its good flavour and vitamins C and G. Empty bottles should be rinsed in cold water, washed, rinsed in hot water, and inverted to drain.

People who do not use milk purchased at a dairy need not take the risk of using unpasteurized (raw) milk. They may pasteurize the milk needed for use at home or school by the method described in experiment 16-1. The milk may be pasteurized in the upper container of a double boiler. Water is heated in the lower container until the milk has remained at a temperature of 143°F. to 145°F. for at least half an hour. Then the milk is cooled rapidly to a temperature of about 50°F.

Last, and most important, to safeguard the health of city and country people alike, only pasteurized milk should be used.

Review and Learning Exercises

1. Rule a page of your notebook in two columns. In the first, list the chief sources of impurities in milk. Opposite these, in the second column, list some precautions necessary to keep these impurities from entering milk.

2. Make a mural or a frieze to illustrate the story of milk from the growing of pasture grass to the use of milk in a dish of cereal at breakfast.

3. Investigate and report to class: the price paid to farmers for raw milk; how cream is graded at a creamery; the present selling price of several common dairy products; the daily duties of a city milkman.

4. Plan and perform an experiment to find out whether milk sours more quickly when kept warm than when kept cool.

5. Study the maps on page 306 of *General Science*, Book 1, to discover what regions of Canada specialize in dairy farming.

Answer These

1. Fill in the blanks in this sentence: "When milk is pasteurized, it is heated to a temperature of°F. and kept at this temperature for minutes, then immediately cooled to a temperature of°F."

2. How do each of the following help to give us safe and palatable milk: testing cows for tuberculosis, sterilizing milk utensils, storing milk at 50°F. or lower, pasteurizing milk, keeping milk covered in the home?

3. Why is each of the following important to the dairy industry: the discoveries of Louis Pasteur, the Babcock test for butterfat, artificial refrigeration?

Your Word List

Pasteurize, diphtheria, bacteria, tuberculosis, dairying, Holstein, sterilize, contamination, communicable disease, infection.

16 mm. Sound Film

Ontario Visual Education Branch

Milk (SN-49)

The Milky Way (colour) (SA-10)

Dairy Industry (VG-7)

National Film Board

Milk-made (production and processing)

Your Morning Milk (how producers, distributors, and consumers keep milk pure)

UNIT SEVEN

Looking Out from the Earth

17. *THE SUN IN RELATION TO THE EARTH*

The sun is man's benefactor. It gives him light, heat, and power. The very existence and the health of all living things, both plant and animal, depend upon this huge, distant, globular ball of fire. The sun is responsible for day and night, for the changes in the length of day and night, and for the seasons. It determines longitude and time, also latitude and the earth's zones of heat and cold.

18. *DISCOVERING NEW WORLDS*

The solar system consists of the sun, the family of planets that revolve round the sun, and all the moons that revolve round the planets. As our moon, devoid of atmosphere and life, circles on its orbit round the earth once a month, we observe its constantly changing phases. Beyond the solar system are myriads of stars, some much larger than others, and some whiter than others because they are hotter. Many of the stars are grouped as constellations; others make up the path of light we call the Milky Way. Moving across the sky from time to time we may see meteors and comets.



17

THE SUN IN RELATION TO THE EARTH

“The glorious sun . . . the centre and soul of our system . . . the lamp that lights it . . . the fire that heats it . . . the magnet that guides and controls it . . . the fountain of colour, which gives its azure to the sky, its verdure to the fields, its rainbow hues to the gay world of flowers . . . ”

—Sir David Brewster

THE EARTH on which we live has always been a mystery to man. Its great size, its high mountain ranges and its wide seas, its tropical jungles and its barren polar lands—all these have kept man busy for thousands of years trying to discover the secrets of the earth.

Gifts of the Sun

Far back in the history of the human race, man worshipped the sun as the source of light, heat, and power—the gifts of a mighty god. It was believed that if the great sun god should ever turn his face from the earth, man’s destruction would surely follow.

The Sun Gives Us Light. Can you imagine our earth without sunlight? We would have to grope our way about in perpetual darkness as black as a moonless night in the open country, with only the feeble light from the stars to show us the way.

The sun is the source of most of our light. When it shines on the part of the earth where we live, we have daylight, although clouds may keep us from actually seeing the sun. Of all kinds of light we obtain from the sun, daylight is the most important. It makes possible all plant life and, therefore, our food, our clothing, and most of our shelter. With the help of daylight, man does most of his work and enjoys much of his recreation. Daylight comes as dawn when the first rays of the sun are reflected from the atmosphere or clouds above us; it ends in evening, fading away in the beautiful colours of sunset.

Moonlight is really sunlight that comes to us in a round-about way. When the sun has set below the horizon and is shining on lands and peoples much farther west, it shines also on the side of the moon facing us. So bright does the light of the sun make the barren surface of the moon, that enough light is reflected from the moon's surface to our earth to let us see our way about with ease. Moonlight is reflected sunlight.

Since most electricity is produced by generators operated by water power or by steam turbines, we may say that electric lighting and heating are made possible by the sun. Let us see if we can explain this statement. When the sun shines on the earth's surface, it causes water to be evaporated and to be carried to higher levels in the form of water vapour. Some of the water vapour condenses and becomes visible to us as clouds. The tiny particles of water that make up the clouds grow into raindrops. The rain feeds the streams, and these flow downwards to the sea. Where man has harnessed the falling water, it spins the turbines which drive electric generators, and these produce the electricity with which we light our homes.

To produce electricity by steam power, we usually burn coal. We have already learned that coal is formed from decomposed

plants that grew millions of years ago with the help of energy from the sun. Therefore, we may truly say that electricity is made possible by the sun.

The sun gives us the many colours we find in nature.

EXPERIMENT 17-1. *Sunlight is made up of several colours.*

Hold in direct sunlight a prism, a piece of bevelled glass, or a rectangular glass vessel containing water. On a piece of white paper, catch the band of colours (spectrum) produced. Name the colours in order.

The glass or the water changed ordinary sunlight into the seven colours of the spectrum—red, orange, yellow, green, blue, indigo, and violet. Beyond the red rays that we see in the spectrum are invisible infra-red rays. These give us heat. Beyond the violet rays of the spectrum are invisible ultra-violet rays which are necessary for the healthful growth of most living things.

When sunlight shines through the raindrops of a shower in early forenoon or late afternoon, we may see a rainbow. The colours in the rainbow are formed from the ordinary white light of the sun as it shines through the raindrops. The drops of water have the same effect on the light passing through them as the glass prism had on the light passing through it.

The Sun Gives Us Heat and Power. On a hot summer day it is easy to realize how much heat the sun gives us. It would be difficult, however, to imagine the whole earth without any heat from the sun. The temperature of all places on the earth, at all times, would be more than 450 Fahrenheit degrees below zero. At such a low temperature there would be no bodies of water, no evaporation to form water vapour in the air, and no clouds. Plants and other forms of life, including ourselves, could not exist.

EXPERIMENT 17-2. *Can the heat of the sun cause burning?*

Hold a lens so that it brings the sun's rays to a point (a focus) on a piece of paper. Does the paper start burning? The lens concentrates enough heat at the focus to warm the paper to its kindling temperature. Then the paper starts to burn.

PUPIL INVESTIGATIONS. *How does the heat of the sun affect man's ways of life?*

1. Find out what parts of the earth's surface have no inhabitants on account of the low temperatures.

2. Make a list of a few very cold countries, some very hot ones, and some with a temperate climate. Find out what effect the temperature has upon the industrial importance of a country, the general activities of the people, and their educational and social progress.

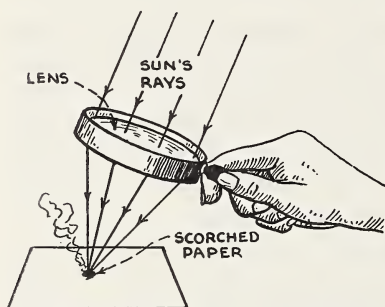


FIG. 17-1.

A LENS HARNESSSES THE SUN'S RAYS.

Heat from the sun makes the earth habitable. The most progressive nations are those whose climate is neither too hot nor too cold. In such temperate countries people can go about their work in comfort most of the year. With climatic conditions so favourable, people develop higher standards of living and of

education, and produce most of the world's food and manufactured articles.

A moderate amount of heat is necessary for all life, both plant and animal. The warmth of the atmosphere and of the soil determines in part how well crops and other plants can grow. In moist, tropical places vegetation grows rapidly and luxuriantly. In temperate regions the grain, fruit, and vegetables we need for food, and the farm crops needed for livestock, grow well. In colder areas there is not enough warmth either for seeds to germinate well or for plants to mature. It is the sun's heat that makes all life possible.

The sun's heat determines our weather. We shall learn in a later chapter how the sun is responsible for wind and calm, rain and storm.

As we explained earlier, the sun is responsible for most of the heat and power we use, whether they come from coal or electricity.

All Life Depends upon the Sun.

“Sunlight is like the breath of life.”

Nathaniel Hawthorne

Plant Life. All plants need light and heat from the sun. Some receive them directly; others, indirectly. In a green plant the leaves are the plant's factories. For raw materials they use water and dissolved minerals from the soil, and carbon dioxide from the air. Their green colouring matter (leaf-green or chlorophyll) is the machinery. Sunlight provides the energy or power that enables the chlorophyll to work. With the help



FIG. 17-2. SOME GIFTS OF THE SUN.

Study the artist's method of showing that the sun gives light, heat, and power; that the sun is essential to plant and animal life; and that it helps to provide facilities for healthful recreation.

of light from the sun, the green leaves change the raw materials into starch and sugar. The starch and sugar enable the plants to live, grow, and produce new plants.

Green plants can grow and reproduce only when the soil and the air are warm enough. The heat that warms the soil and the air comes from the sun.

Mushrooms, puffballs, bracket fungi on trees, and other plants without chlorophyll cannot make their own food, even when they do receive sunlight. They obtain their nourishment from living or dead plants, or from the remains of dead plants. But the light and the heat of the sun made possible the green plants upon which plants without chlorophyll feed. In this way, these special plants also depend upon the sun for their food. To live and grow, they also require warmth, and this, too, comes from the sun.

Animal Life. Some animals feed upon plants; some eat the flesh of other animals; others eat both plant and animal foods. Because all plants depend upon the sun, so must all animals that feed upon plants. Our first thought may be that flesh-eating animals do not depend upon the sun for their food. Consider the cat. It may be nourished by vegetable scraps from our tables, the flesh of mice, canned or fresh meat, or milk. Of course, the vegetable scraps came from plants that used the light and heat of the sun. The mice eaten by the cat depended upon the sun because they fed upon plant foods. The farm animals from which the meat and milk came fed upon green plants or their products. Because the sun made the farm crops possible, it made the meat and milk possible, too. Hence, the cat depends upon the sun for its food. In a similar manner, all animals, whether they eat vegetable matter or flesh, depend upon the sun, either directly or indirectly, for their food.

Animals, including man, domestic animals, and wildlife, require heat. In some warm climates they obtain all the heat they need directly from the sun and from their surroundings, which are heated by the sun. Elsewhere, clothing or some kind of protective shelter is required. Man's clothing, whether it be

of cotton, linen, rayon, silk, wool, fur, or leather, comes from plants, or from animals that feed upon plants. Therefore, man depends upon the sun for the raw materials for his clothing. The shelter of man and other animals may take the form of homes, barns, shrubbery, or hollow trees. All of these types of shelter make some use of plants and, therefore, depend upon the sun.

The heat that keeps man's temperature normal comes indirectly from the sun. Our body warmth is produced by the food we digest. As digested food circulates in the blood stream, it combines with oxygen, somewhat as fuel does when it burns in a furnace. Our food fuel, like the coal in the furnace, produces heat. Because the sun makes possible the plants and animals from which our food is derived, it is indirectly the source of all body heat.

The Sun Contributes to Good Health. Good health depends upon good food, fresh air that is sufficiently warm and humid, freedom from harmful germs, and sufficient healthful recreation. Sunlight not only makes possible all our foods, including fruits, vegetables, meats, milk, and dairy products; it affects their quality as well, and, therefore, our health. In sunlight, the leaves of green plants give off the oxygen we need for breathing. The sun warms the air and, by evaporation of water, keeps it healthfully humid. The sun is an important factor in our choice of places for sports and other forms of recreation.

The sun helps to prevent disease in two important ways. Direct sunlight causes the health-giving vitamin D to be formed in our skin, and plays a vital role in the growth of oranges, tomatoes, and other foods rich in vitamin C. Sunlight kills disease-producing germs in the air we breathe and in the water we drink.

We can have too much direct sunlight and, as a result, suffer from sunburn or sunstroke. Therefore, precautions should be taken to prevent too much exposure to direct sunlight until a protective tan has been developed in the skin.

The Nature of the Sun

The large size and the extreme brightness of the sun make it the most conspicuous of all heavenly bodies. The heat and light it gives the earth make it the most important to us, for these gifts make all life possible and contribute to the health of every living thing. Like the earth, all other planets are held in their courses by the gravity of the sun. Like many people before us, we might well ask what characteristics of the sun enable it to serve us in so many ways.

The Size of the Sun and Its Distance from the Earth. How deceiving the size of the sun is as we look at it with the naked eyes! A basketball 100 feet away, held in line with the eye and the sun, is large enough to keep the sun's rays from reaching us. But the diameter of the sun, 866,000 miles, is so long that 109 earths could be strung along it like beads, and its volume is so great that more than a million earths could be packed inside it. If we were to represent the earth by placing a pea on the ground, a beach ball two feet in diameter would have to be placed about 75 yards away to represent the sun. Because of its great size, the sun exerts a very strong pull upon any object. This pull is known as *gravity*. Gravity towards the sun is so great that an object near it would weigh 28 times as much as it would near the earth.

We might wonder how we on earth can safely use the intense heat and light of the sun. The secret lies in its great distance from us, for the sun is 93,000,000 miles from the earth. You will understand better how great this distance is when you work out the following problem.

A PROBLEM.

Count to ten at the rate of one a second. Imagine yourself travelling 10 miles in a new kind of aeroplane, or in a rocket, in that length of time—a rate of 60 miles a minute. At this speed, how far would you travel in a school day of six hours? In a school week? In the forty weeks of a school year? How many such years would it take you to travel 93,000,000 miles? If your chum were to spend the next ten years in high school and university, how long would he be working at his profession before you could reach the sun?

Heat and Light from the Sun. We think of molten iron as being very hot. Now let us imagine a huge globe of metals so hot that they are no longer solid, or even liquid, but have become a fiery mass of gases with a temperature of perhaps $10,000^{\circ}\text{F.}$ at the surface, and many millions of degrees F. in the centre. Such is our sun.

Observed through a smoked glass, the sun appears to be a smooth disk of light. In reality, it is a huge mass of gases so very hot that it gives forth light more intense than we can imagine. Light takes time to travel, but it travels very quickly. Only a second is required for light to travel 186,000 miles. The sunlight now shining through your window left the sun about eight minutes ago.

We say that light from the sun or an electric light bulb is radiated out in all directions. We speak also of light as travelling in *rays*. Rays of light travel in straight lines. For this reason, a tree or a pole casts a shadow: the rays of light cannot curve around such objects.

The Sun Causes Day and Night

The Sun's Apparent Path through the Sky during a Day. For thousands of years man has watched the sun rise in the east and set in the west. Early man thought it came out of the sea daily at one side of the earth and returned into it at the other side of the earth. At the same time he thought the earth was flat. In fact, most men held this belief until the 16th and 17th centuries. However, as early as the second century A.D. scientists were investigating the idea of the earth being a sphere with the sun and other planets revolving round it. You can make investigations similar to theirs.

PUPIL INVESTIGATIONS. *Observe the sun's apparent path through the sky during a day.*

Notice the position of the sun in the sky at sunrise, at 10 a.m., at noon, at 3 p.m., and at sunset. Make a drawing to show the sun's position at the time of each observation. Draw a line to connect the various positions of the sun. Describe the shape and the position of the path the sun seems to follow.

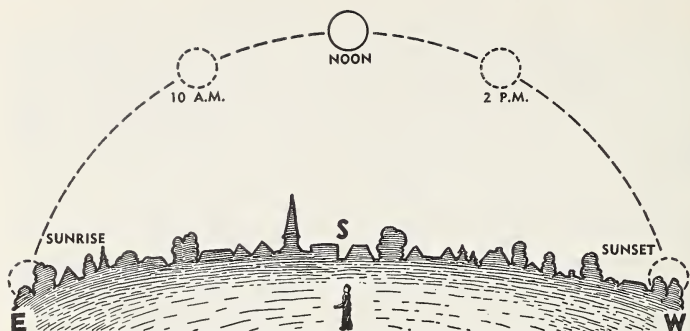


FIG. 17-3. THE SUN'S APPARENT PATH ACROSS THE SKY EACH DAY.

A good scientist, or any person with a fair degree of curiosity, tries to find out the cause of what he sees happening. Doubtless, during your investigations you saw the sun rise in the east, curve southwards and upwards to its highest point in the sky, directly south of you at noon, then sink lower in the sky as it curved round from the south to the west. Finally you observed the sun setting nearly to the west of you. Curiosity should make you ask "Why?"

In driving along a highway towards the east, you may have noticed a building or a large tree far ahead of you, apparently almost due east of you. As you came closer to the object, it seemed to move to the south and west. Soon the object was due south of you, but only for an instant. Then it seemed to move off to the west. But you know it did not move. Instead, you moved eastwards, came opposite the object, then passed it and left it farther and farther behind. Think of the tree as the far-away sun, and of the earth as the automobile carrying you along. As the tree did not move towards you and to the south, neither does the sun. Just as the automobile continually carried you to the east, so the earth continually carries you eastwards. In early morning the sun is far to the east. By 10 a.m. you have been carried eastwards by the earth far enough to make the sun appear south-east of you. By noon you are opposite the sun, and it is seen to the south. As the afternoon passes, you leave the sun

farther and farther behind, first to the south-west, and finally far to the west of you—out of sight. Then, day is done.

Day and Night, Caused by the Rotation of the Earth. Why does the sun appear to rise in the east and set in the west? Man took thousands of years to answer this. Now we know the earth turns round and round, much as an apple can be turned if we put a knitting needle through its centre. We say the earth *rotates*. It rotates on an imaginary line, the *axis*, extending from the North Pole to the South Pole, and requires a day of 24 hours to make one complete turn or rotation. We call it a day from the time the rotating earth brings us to a point directly north of the sun (noon) until it brings us to the same position the next noon. In fact, our timepieces begin to count time at 12 noon.

PUPIL INVESTIGATIONS. *The earth's rotation causes day and night.*

Place a plasticine man on the globe. Direct the light of a flashlight to the globe so that the rays of light would appear to the man to be just visible on the horizon. Next, rotate the globe until the light shines vertically over the man's head. Keep rotating the globe until the light would seem to the man to disappear below the horizon on the other side of him. The light would appear to him as the sun rising, passing over his head, and setting. Rotate the globe again. This time, observe the place where you live as it comes into light (sunrise or dawn) and later passes out of sight of the sun (sunset). How much of the globe is lighted at one time by the flashlight?

The sun, represented by the flashlight shining on the globe, can light only half the earth at once. The lighted half has day while the other half has night. Where the two halves meet is an area only partially lighted. This twilight area is seen as dawn on the part of the earth emerging *into* the sun's light, and as sunset on the part of the earth passing *from* the sun's light.

PUPIL INVESTIGATIONS. *How fast does the rotating earth move?*

Use an orange to represent the earth. Push a knitting needle through the centre of the orange to represent the axis through the earth. Insert a pin in the orange half way between the North Pole and the equator (about where you live). Rotate the orange until the pin-head moves once round.

The distance that the pin has travelled represents about 16,000 miles on the earth, and the time that it required to do so represents 24 hours. Thus, we realize that we in southern Canada are spinning along with the rotating earth at about 700 miles an hour.

Why, then, does the sun appear to move across the sky so slowly? A nearby car travelling at 50 miles an hour seems to travel much more rapidly than a distant aeroplane travelling at 200 miles an hour. The distance that separates us from the moving object makes the difference. We have already learned of the great distance between our earth and the sun.

The Sun, Longitude, and Time

Longitude and Distance. There is a more convenient method of measuring distance round the earth than by measuring it in miles. You have measured the circumference of a circle in inches, and the size of an angle in degrees. But these two methods are very similar.

PUPIL INVESTIGATIONS.
How do we measure circles?

Draw a circle. Keeping the compass set with the same radius, use it to divide the circumference into six equal parts. Join the dividing points to the centre. Measure the angles formed at the centre. They total 360 degrees. Just as each angle measures 60 degrees, so the part of the circumference opposite the angle measures 60 degrees, and the whole circumference, 360 degrees. All circles or parts of circles may be measured in degrees.

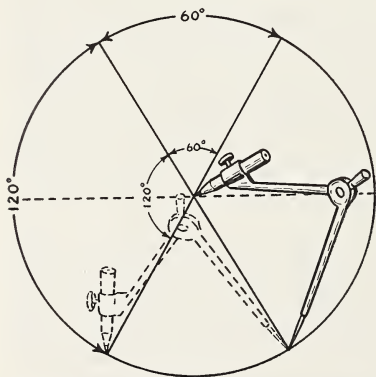


FIG. 17-4. MEASURING CIRCLES IN DEGREES.

The circumference of the earth at the equator is a circle. Therefore, the circumference of the earth consists of 360 degrees. Now look at the globe. You see lines crossing the equator line at right angles to it every 15 degrees. These lines are called

Meridians of Longitude; the spaces between them are 15 degrees of longitude wide. All meridians extend from pole to pole. By means of these meridians, we can decide how far, in degrees, places are east or west of each other.

At the equator the earth is 25,000 miles around. Therefore, each degree of longitude at the equator equals approximately 69 miles. The meridians come closer together in miles near the poles, but remain the same distance apart in degrees. At the poles, all meridians meet in a point.

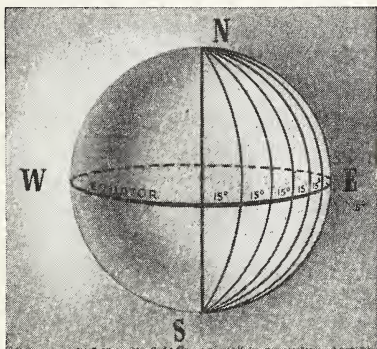


FIG. 17-5. MERIDIANS OF LONGITUDE.

Longitude is used to locate positions east and west on the earth. In order to establish a system of measurements in degrees east and west, it was necessary to decide upon a starting point.

The meridian that passes through Greenwich, England, was selected as the starting point, and it is labelled 0 degrees Longitude (usually written 0° Longitude). A meridian 15 degrees west of this is called 15° West Longitude; one 60 degrees east of it is called 60° East Longitude. A map shows St. John, N.B., at 66° West Longitude; Windsor, Ontario, at 83° West Longitude; and Madras, India, at 80°

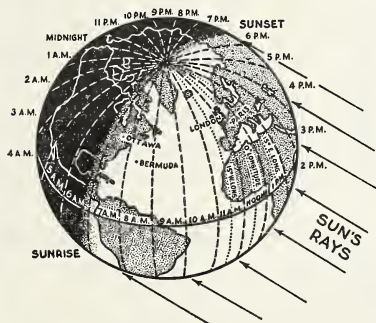


FIG. 17-6.

STANDARD TIME ROUND THE WORLD. Find the meridian of longitude through Greenwich, England, labelled 0° . Now find the meridians at $7\frac{1}{2}^{\circ}$ West Longitude and $7\frac{1}{2}^{\circ}$ East Longitude. All places between these meridians have the same standard time.

East Longitude. As there are 360 degrees in a circle, east and west longitudes meet at 180° East or West Longitudes.

PUPIL INVESTIGATIONS. *Reading a map to determine longitudes.*

Find the longitude of each provincial capital in Canada; also the longitude of Berlin, Moscow, Paris, Rome, Washington, and New Orleans.

Sun Time and Standard Time. As you stand on the rotating earth, you are much like the hour hand of a watch. When the hour hand passes directly over the figure twelve, it is noon. So, too, when you have been carried by the moving earth to where the sun shines vertically over your meridian, although to the south of you, you have noon (sun time, or solar time). For people 15 degrees of longitude to the east of you, the sun time would be 1 p.m., for they passed the noon position one hour ($15/360$ of 24 hours) before you. For a similar reason, the sun time for people 15 degrees west of you is 11 a.m. What is the sun time for people 75 degrees to the west of you? For people 45 degrees to the west? For people 90 degrees to the east?

Sun time is accurate, but inconvenient. Any two places east and west of each other, no matter how close, have different sun times. If sun time were in general use, a traveller in Ontario going from Windsor to Hamilton, three degrees farther east, would have to advance his watch 12 minutes ($3/15$ of one hour) to have it correct with Hamilton sun time. When he moved on to Toronto, the traveller would have to advance his watch another four minutes. How confusing travel and communication would be!

To avoid these difficulties throughout the world, a convenient system of time belts was decided upon at an international conference. Just as our watches and clocks divide the day into 24 hours, so it was decided to divide the earth into 24 time belts. Having measured the distance around the earth in degrees, 360 of them, each belt was made 15 degrees wide to represent the distance the earth rotates in one hour. Although the sun time at one side of a belt would be one hour faster than the sun time at the other side, it was decided that all places in the belt should

have the same time, namely the sun time of places on a meridian at or near the centre of the belt. This time was to be called their *standard time* (S.T.). Fig. 17-6 shows the meridian through Greenwich, England (0° Longitude), which serves as a starting point for the system of meridians and time belts. All places within $7\frac{1}{2}$ degrees east and $7\frac{1}{2}$ degrees west of this meridian take the sun time of places on the meridian as their standard time.

Canada is divided into seven time belts or time zones. Beginning at the east coast and travelling westwards, a traveller would pass through the Newfoundland, the Atlantic, the Eastern, the Central, the Mountain, and the Pacific Time Zones. Yukon is the seventh time zone. All places in Canada from Fort William eastwards to Rivière du Loup, Que., are in the Eastern Time Zone. Standard time for this area is the sun time of the meridian at 75° West Longitude, near Ottawa. Fig. 17-7 shows how the boundaries between the time belts in Canada were

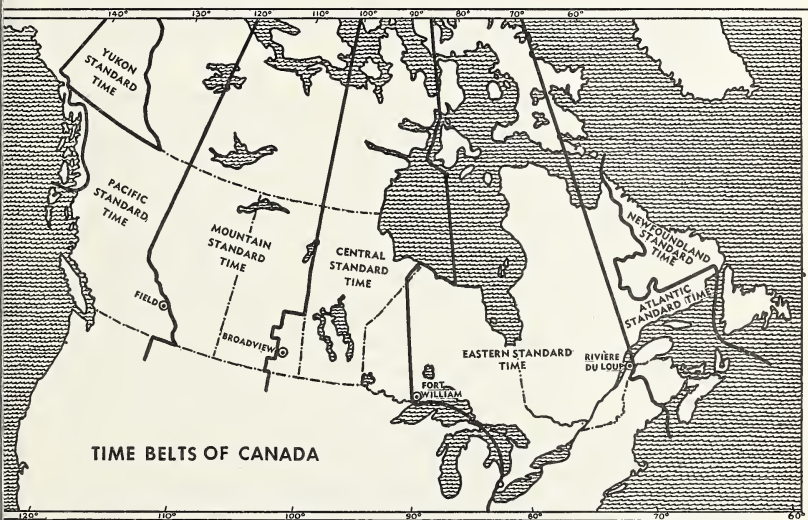


FIG. 17-7. CANADIAN TIME BELTS.

What is the time at Edmonton when it is 9 p.m. at Ottawa? Where does one change time travelling from North Bay to Winnipeg?

placed to provide the same time for nearly all people in each of the following regions: Yukon, British Columbia, Alberta, Manitoba, Ontario and Quebec, the Maritime Provinces, and Newfoundland.

When travelling across Canada, we must change our watches every time we enter a different time zone. These changes are made between Newfoundland and Nova Scotia, at Rivière du Loup (Que.), at Fort William (Ont.), at Broadview (Sask.), and at Field (B.C.). When travelling westwards, we move our watches back an hour at each change of time zone; when travelling eastwards, we set our watches an hour ahead at each of these points. There is one exception: Newfoundland standard time is only half an hour ahead of standard time in the Atlantic Time Zone.

QUESTIONS.

At what hour would a radio programme, broadcasted from London, England, at 8 p.m., S.T., be heard at Halifax? At Montreal? At Windsor? At Regina? At Vancouver?

Daylight Saving Time. In summer, each day has more hours of daylight than at any other time of the year. Then, dawn comes at a very early hour, and several hours of daylight pass before the customary time at which people begin their daily activities. Instead of beginning activities an hour earlier by the clock, it was decided to move all clocks ahead one hour during the summer months. Under this new system of "summer time" or "daylight saving time" all activities commence an hour earlier by the sun, but at the same time as previously by the clock. In this way, we make good use of an extra hour of daylight without disturbing our regular time schedules. Because our work activities end an hour earlier under daylight saving time, the extra hour of daylight is available at the end of the day for outdoor recreation. Under daylight saving time most people save electric power by using electric lights for an hour less each evening. Of course, great inconveniences to business and travel result when only part of a country uses daylight saving time.

Things To Do

1. Determine whether your standard time is fast or slow as compared with your sun time, and by how much.
2. Debate the subject: "Resolved that it is in the best interests of Canada for all places in this country to operate under daylight saving time in summer."

The Sun Causes the Seasons and the Changing Lengths of Day

Through the Four Seasons. To dwellers in temperate regions the four seasons of the year have always been of vital concern. The time of year has determined man's work and play, his food and shelter, and his time of planting and harvesting. Doubtless the earliest inhabitants knew that the sun became higher in the sky at noon as winter changed to spring, and lower in the sky as summer gave way to autumn and winter. Probably they watched new life, both plant and animal, come forth in spring as the days became warmer and longer, and saw vegetation mature in summer heat. Perhaps they tried to find the causes.

The Higher the Sun Is in the Sky, the More Heat We Receive from It. Like our ancestors, we know that the sun is higher in the sky in summer than in winter. We know, too, that we receive more heat from the sun in summer than in winter. Some careful observations of the sun at noon will prove to us that, as winter changes to spring and spring to summer, the sun's course keeps rising higher and higher in the sky.

EXPERIMENT 17-3. *Does the approach of summer affect the length of shadows?*

(a) Attach a long, sharp pencil vertically just inside a south window, as in fig. 17-8,A. Measure the length of the pencil's shadow at noon once every two weeks from February until June. Make a table to show the dates and lengths of the shadows. How does the length of shadow change as summer approaches? What does this tell you about the change in the height of the sun in the sky at noon as the seasons change?

(b) Place a piece of cardboard with a small hole in it against the glass of a south window. See fig. 17-8,B. Lay a piece of paper on the window ledge to show the patch of light caused by the sun shining through the hole. Attach the paper securely so that it cannot move. Trace around the spot of light at noon each day for two weeks or more, and then once a week until June. Write the date beside each mark. Compare these observations with those in experiment 17-3(a).

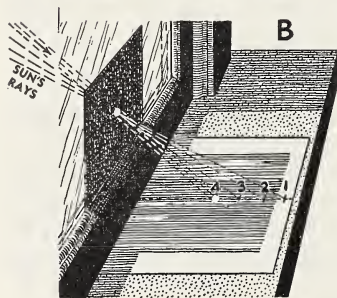
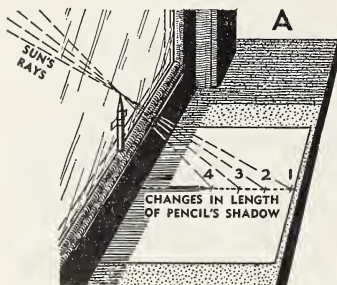


FIG. 17-8. OBSERVING CHANGES IN THE ELEVATION OF THE SUN.

A change in the length of the sun's shadow accompanies a change in the height of the sun in the sky.

These experiments should convince you that the sun becomes higher and higher in the sky at noon from winter until June 21st. Another investigation should help you to understand what effect the height of the sun in the sky has upon the amount of heat we receive from it.

PUPIL INVESTIGATIONS. *How does the height of the sun in the sky affect the amount of heat we receive from it?*

Stand in your classroom and face south. Point to the position of the sun at sunrise. Notice the direction of your arm. Point to the position of the sun at 10 a.m., at noon, at 3 p.m., at sunset. At what hour do we receive most heat from the sun? At what hour is it highest in the sky? At what hour are its rays almost perpendicular to the earth?

We receive more heat from the sun at noon, when it is highest in the sky, than we do earlier or later in the day, when it is lower in the sky.

EXPERIMENT 17-4. *How does the angle of the sun's rays determine the amount of heat the earth receives?*

Join together two boards to form a right angle, as shown in fig. 17-9. Cover the inside surface of each board with black paper. Suspend a large electric light bulb as shown. Attach thermometer A to the vertical board so that only the perpendicular rays from the light approach the paper behind the thermometer bulb. Place thermometer B on the horizontal board so that the paper behind its bulb receives only slanting rays from the light. Be sure that both thermometer bulbs are the same distance from the light. Leave the light turned on for 10 minutes. How does the amount of heat given to thermometer A by the part of the paper receiving the perpendicular rays compare with the amount of heat given to thermometer B by the part of the paper receiving slanting rays? Yes, the perpendicular rays heated the paper behind thermometer A more than the slanting rays heated the paper behind thermometer B.

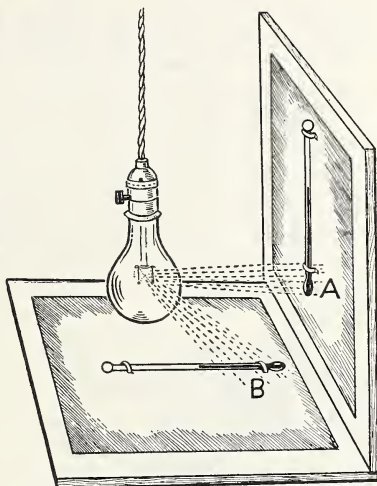


FIG. 17-9. PERPENDICULAR RAYS GIVE MORE HEAT THAN SLANTING RAYS.

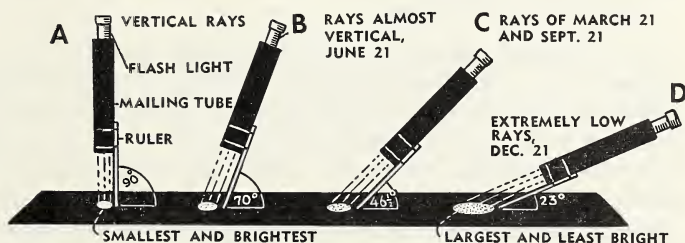


FIG. 17-10. THE MORE NEARLY VERTICAL THE SUN'S RAYS, THE BRIGHTER THE LIGHT THEY GIVE.

EXPERIMENT 17-5. *Why does the angle of the sun's rays determine the amount of light and heat the earth receives?*

(a) Attach a flashlight, mailing tube, and ruler in the manner shown in fig. 17-10. The flashlight represents the sun, and the top of the table represents the earth. Direct the light to the top of the table at the angles shown in A, B, C, and D, and observe the size and brightness of the lighted spot for each angle. How does the brightness of the spot change as its area increases?

(b) Use the flashlight and mailing tube without the ruler, as shown in fig. 17-11, to direct light vertically over the equator line on a globe; then, from the same distance, direct the light obliquely to a place in a northern latitude. Compare the size and the brightness of the areas lighted.

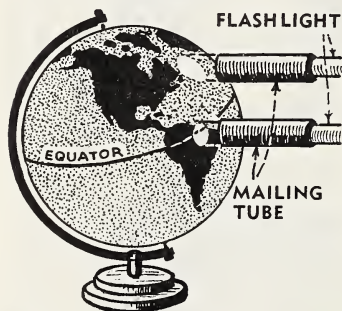


FIG. 17-11. COMPARING THE LIGHTING AND HEATING EFFECTS OF PERPENDICULAR AND SLANTING RAYS OF THE SUN.

Why does the sun make it warmer in Brazil than near Labrador?

Let us suppose the flashlight represents the sun radiating light and heat. The amount of light and heat radiated does not vary. Therefore, the amount of light and heat received by the surface under the small, bright spot, and the amount of light and heat received by the surface under the larger spot, would be the same. But the small spot would be brighter and warmer than the larger spot because the light and heat would not have to spread over so large an area.

Three reasons account for our winters being colder than our summers. Our experiments with the flashlight show the first reason. The sun's rays that reach our part of the earth are more slanted in winter than in summer. This causes the sun's light and heat to be spread over a larger area. As a result, each place receives less light and heat in winter than it receives in summer when the sun's rays approach the same place more nearly vertically. Secondly, our flashlight shining on the globe showed that slanting rays from the sun pass through more atmosphere on

their way to the earth than do rays that fall more nearly perpendicularly. Therefore, slanting rays lose more heat than vertical rays before they reach the earth, and have less heat left to give to the earth. Thirdly, winter days are shorter than summer days, giving the sun less time to heat the earth.

In Canada, the sun's rays reach us the most nearly vertically about June 21. At that time of the year we receive the most heat from the sun. Our weather continues to become hotter, however, for another month or more. Why is this? As the land and water round us continue to receive heat from the sun throughout the summer, they continually become warmer and warmer. In early autumn, when the sun is again low in the sky, the earth loses heat faster than it receives it. Then the earth cools off, and we say the weather is colder.

The sun is in its lowest position in the sky on December 21. Our coldest weather comes later, after the sun's position has started to become higher in the sky. This is because the earth continues to lose heat in January more rapidly than it receives it from the sun.

How the Sun Warms the Earth.

PUPIL INVESTIGATIONS.

While the sun is shining through a window onto a nearby table, feel the windowpane, the top of the table, and the air between them. Which is warmest? Which is coldest? Why? The heat that warmed the table passed through the cold glass and, before that, through the cold air.

Little heat is absorbed by the atmosphere as the sun's rays pass through it to the earth; but the surface of the earth, like the top of the table, absorbs the sun's heat freely. Most of the heat that we feel is being radiated from the warm earth after being absorbed by it. Clouds reduce the amount of heat that reaches the earth from the sun, making the earth cooler on cloudy days in summer. Clouds also reduce the amount of heat lost by the earth to the atmosphere, and so prevent frosts on cloudy nights in autumn.

Dark-coloured objects take in more heat from the sun than do light-coloured objects. This explains why we are cooler in summer when dressed in light-coloured clothing; why dark soil warms more quickly than light-coloured soil in spring, other conditions being the same; and why dirty snow melts more quickly than clean snow.

Why We Have Different Seasons, and Days of Unequal Length.

We learned earlier in this chapter that the earth travels round the sun once each year. The course that the earth follows is almost a circle with the sun at its centre. We call this invisible path the earth's orbit, and we say that the earth revolves round the sun, or makes a revolution on its orbit, once a year.

PUPIL INVESTIGATIONS. *Find the causes of the changes in seasons, and of changes in the lengths of days and nights.*

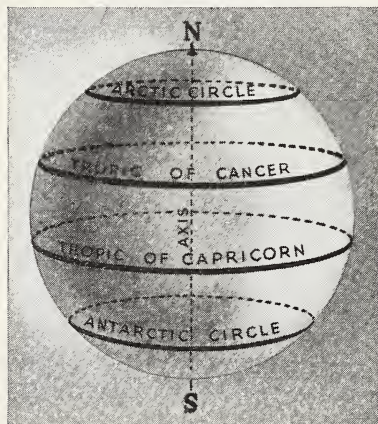


FIG. 17-12. FOUR IMPORTANT CIRCLES AROUND THE EARTH.

The equator is half way between the Tropic of Cancer and the Tropic of Capricorn.

For these investigations you will need a globe to represent the earth, a good flashlight to represent the sun, and a table or a stool set in the centre of each of the north, south, east, and west sides of the room. The classroom should be darkened.

1. Find the Tropic of Cancer and the Tropic of Capricorn on the globe. Direct light from the flashlight perpendicularly over the Tropic of Cancer. Rotate the globe. As you do this, compare the lengths of day and of night indicated at the equator, north of it, and south of it. Direct the light of the flashlight perpendicularly over the Tropic of Capricorn, and rotate the globe again. Make the same comparisons as above.

When the sun shines vertically over the Tropic of Cancer, all places in the Northern Hemisphere have longer days than nights, and all places in the Southern Hemisphere have longer nights than days. When the sun shines vertically over the Tropic of Capricorn, days are longer than nights south of the equator, and shorter north of it.

2. Set the globe so that its axis is vertical. Have one pupil carry the globe all the way round the room, stopping at each side to rest it on the table for observation. The course the pupil takes will represent the invisible path of the earth in its revolution round the sun. Have another pupil stand in the centre of the room and use the flashlight to represent the sun. The pupil should keep the beam of light from the flashlight (the sun) shining directly on the globe as his classmate carries it round the room. This activity helps to explain the yearly revolution of the earth round the sun.

When the earth's axis is vertical, which parallel of latitude receives the perpendicular rays of light? Mark your location on the globe. Have a pupil carry the globe round the room again while you think of it as the earth revolving round the sun. Rotate the globe from time to time to illustrate the passing of day and night. How would the days and nights at your location compare in length? Is this true at all four points of observation? What season would you always have if the earth's axis were always vertical and the sun's perpendicular rays always shone over the equator? Answer these same questions for other places on the globe.

If the earth's axis were always vertical, the angle of the sun's rays to any place on the earth would always be the same throughout the year. Therefore, each place would have days and nights of equal length, also the same season, throughout the year. But we have four seasons. Therefore, something else besides the earth's revolution must account for the change of seasons and the change in length of day and night.

3. Tilt the axis of the globe to an angle of $23\frac{1}{2}$ degrees. Have the globe carried round the room as before, keeping the North Pole always towards the centre of the room. Rotate the globe in each of the four stopping positions. What season would places in the Northern Hemisphere have? Places in the Southern Hemisphere? How would the length of day compare with that of night north of the equator? South of the equator?

This demonstration shows us that the same season would go on forever throughout the earth if the north end of the earth's axis always leaned towards the sun as the earth revolved round it. The revolution of the earth round the sun, and the inclination of the earth's axis, are not sufficient to explain the change of seasons and the change in length of day and night. There must be another cause.

4. Leave the axis of the globe inclined at $23\frac{1}{2}$ degrees. Have the globe carried round the room again, but, this time, be sure that its North Pole points constantly towards the north—just as the real North Pole of the earth points constantly towards the North Star as the earth revolves round the sun.

(a) Place the globe on the table at the north side of the room. With the flashlight, direct a beam of light onto the globe. Rotate the globe. On what part of the globe do the perpendicular rays of light always shine now? What parts have summer? Winter? What parts have longer days than nights? Shorter days than nights?

This position of the globe in relation to the flashlight represents the position of the earth in relation to the sun on December 21. Then the perpendicular rays of the sun fall directly on the line we call the Tropic of Capricorn. At this time, all places north of the equator have winter, with days shorter than nights; all places in the Southern Hemisphere have summer, with days longer than nights; and the sun's rays shine $23\frac{1}{2}$ degrees past the South Pole, to the Antarctic Circle, bathing this region in continuous daylight. Study fig. 17-13 and then copy it in your notebook.

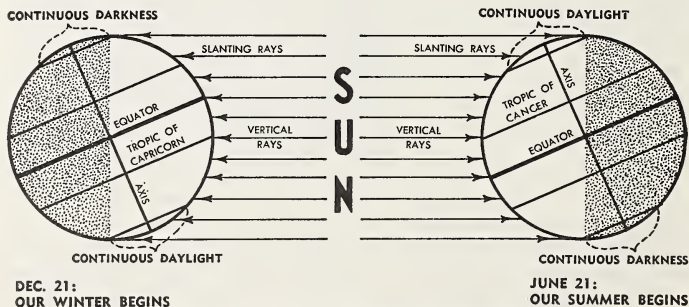


FIG. 17-13. HOW THE SUN CAUSES WINTER AND SUMMER.

(b) Place the globe on the table at the west side of the room. Be sure the North Pole of the globe still points to the north. Again direct the beam of light from the flashlight onto the globe and rotate the globe. The perpendicular rays now shine over the equator. What season is demonstrated for the Northern Hemisphere? For the Southern Hemisphere? How do days and nights compare in length in various parts of the earth?

This position of the globe in relation to the flashlight represents the position of the earth in relation to the sun on March 21. The sun then shines perpendicularly over the equator. Spring is beginning for us, and day and night are of equal length at all places on the earth.

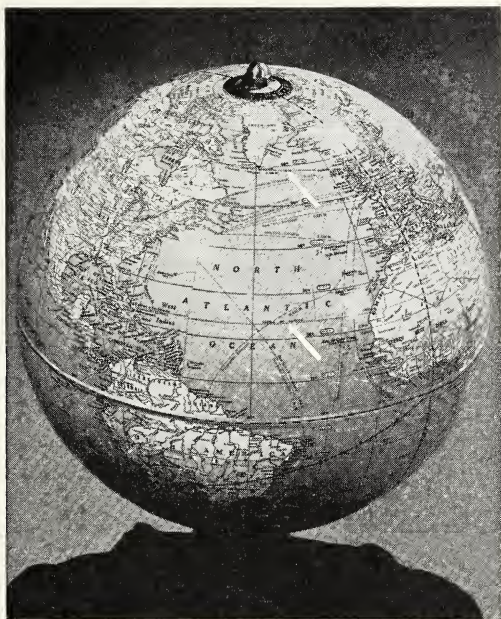


FIG. 17-14. A PHOTOGRAPH OF A GLOBE.

This photograph represents the position of the earth in relation to the sun on June 21. The white arrows point to the Tropic of Cancer and the Arctic Circle.

(c) Move the globe to the table at the south side of the room. Direct the beam of light onto the globe again. Rotate the globe. Answer the same questions as for (a).

When the earth and the sun are in the positions represented by your globe and flashlight in (c), on June 21, the perpendicular rays of the sun shine directly over the Tropic of Cancer. The most slanting rays shine past the North Pole to the Arctic Circle, giving that area continuous daylight. Then, we have our longest day and our shortest night. See figs. 17-13 and 17-14.

(d) Move the globe to the table at the east side of the room. Rotate the globe. Decide what season each hemisphere has. Compare the lengths of day and night in various places on the earth's surface.

These positions of the globe and the flashlight represent the positions of the earth and the sun on September 21. The sun then shines perpendicularly over the equator. Autumn is beginning for us, and day and night are of equal length at all places on the earth.

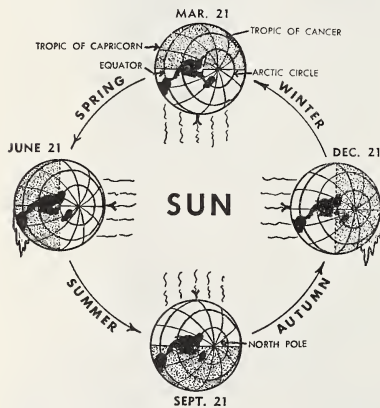


FIG. 17-15. THE SEASONS COME AND GO.

This figure illustrates the revolution of the earth on its orbit round the sun once a year. In all drawings, the North Pole faces towards us. The arrows indicating the sun's rays approaching the earth vertically point to the following circles: Mar. 21, the equator; June 21, the Tropic of Cancer; Sept. 21, the equator; and Dec. 21, the Tropic of Capricorn.

Now, review the causes of seasons by studying fig. 17-15 and answering the following questions: Why are the icicles shown on the Southern Hemisphere on June 21 and on the Northern Hemisphere on Dec. 21? How far past the North Pole do the sun's rays reach on June 21? On what dates does the line separating day and night pass through both the North Pole and the South Pole? How do the lengths of day and night compare

on all parts of the earth on March 21 and on Sept. 21? At what time of year does the North Pole have continuous daylight?

The Earth's Surface Is Heated Unequally by the Sun. Every time we purchase coffee from Brazil, oranges from Florida, peaches from the Niagara Peninsula, and apples from more northerly parts of Ontario, we are reminded of the differences in climate of places near to and farther from the equator. The cause of this unequal heating of various parts of the earth is somewhat similar to the cause of seasons.

The vertical rays of the sun never shine on places farther north than the Tropic of Cancer, nor on places farther south than the Tropic of Capricorn. Therefore, places between these circles receive more heat than places elsewhere on the earth. We speak of the regions of the earth between the Tropics as being *tropical regions* and as having a *tropical climate*, and we describe their fruits as tropical fruits.

Near each of the two poles is an area on which only the most slanting rays of the sun ever shine. These rays give so little heat to the earth's surface that the summers are very short and

cool and the winters are extremely cold. We speak of these areas of the earth near the poles as *polar regions*, and we describe their climate as *frigid*.

Canada, Europe, Argentina, and other areas of the earth between the tropics and the polar regions, both north and south of the equator, have a temperate climate. The farther a place is from the equator, the cooler it is likely to be unless its altitude or the presence of

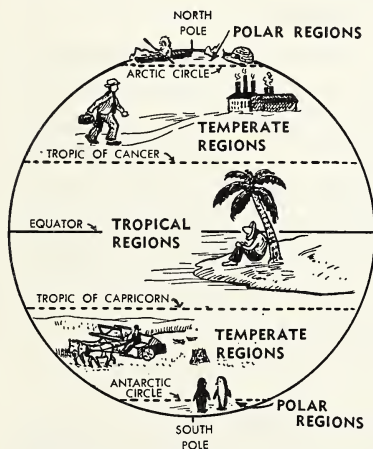


FIG. 17-16. THE EARTH IS HEATED UNEQUALLY BY THE SUN.

large bodies of water influence its temperature otherwise. Places with a high altitude are colder than those at lower levels but at the same distance from the equator. The presence of large bodies of water nearby tends to make winters less cold and summers less hot than they would be otherwise. Because the *temperate regions* of the earth have neither the extreme cold of polar areas nor the intense heat of the tropics, they have developed the highest types of civilization.

We should remember that the changes in temperature and in life from the equator to the poles is gradual, without any abrupt changes—somewhat like the changes that we experience when summer changes to autumn, and autumn to winter.

Because temperature and distance from the equator are so closely related, we should understand how to measure both of these. We have already learned how to use a thermometer to measure temperature; we shall now learn how to measure distance north and south of the equator.

Latitude Measures Distance North and South of the Equator

Just as distance east and west is measured in degrees of longitude, so distance north and south of the equator is measured in degrees of *latitude*. The distance around the earth through the poles is 360 degrees. Therefore, the distance from the equator to either pole is 90 degrees. Maps and globes show that the equator is labelled 0° Latitude, the North Pole 90° North Latitude, and the South Pole 90° South Latitude. Because Sarnia is 43 degrees north of the equator, its location is described as 43° North Latitude; Buenos Aires, 35 degrees south of the equator, is at 35° South Latitude; Londonderry, Northern Ireland, on the fifty-fifth parallel of latitude north of the equator, is at 55° North Latitude.

When both the latitude and the longitude of a place are given, its location is definitely known. A vessel stranded at sea sends out an S.O.S. giving its exact location in degrees North or South

Latitude and in degrees East or West Longitude. The would-be rescuer, knowing where to go, can radio back similar information and advise that he is on his way to the rescue.

Answer These

1. How do you know that sunlight is made up of different colours?
2. How do plants depend upon (a) the light of the sun, (b) the heat of the sun?
3. In what ways does the sun promote good health?
4. When is our longest day? Our shortest day?
5. What movement of the earth causes day and night?
6. What movement of the earth helps to cause changes in seasons and unequal day and night?
7. What is the latitude of the Tropic of Cancer? The Tropic of Capricorn?
8. Why is it possible to hear a midnight news summary from England while it is yet early evening here?
9. What are some advantages of daylight saving time?
10. How does the height of the sun in the sky affect the amount of heat we receive from it?
11. As a day becomes warmer, which is heated first, the soil or the air above it?
12. What city is nearest to: 43° North Latitude and 80° West Longitude? 40° South Latitude and 20° East Longitude? 30° North Latitude and 30° East Longitude? $23\frac{1}{2}^{\circ}$ South Latitude and 43° West Longitude?

Explain These

1. Day and night are caused by the earth's rotation.
2. The varieties of life in the different zones of the earth are determined largely by the various angles of the sun's rays.
3. If the earth's axis were vertical, we could have only one season.

Your Word List

Rotation, revolution, latitude, longitude, meridian, perpendicular, vertical, standard time, daylight saving time.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Finding Your Way by Latitude and Longitude", Vol. KL, pp. 132-135; "Our Giant Sun and Its Giant Tasks", Vol. S, pp. 450-453; "How the Earth Goes around the Sun", "How We See the Sun through the Year", Vol. A, pp. 432-437; "The Wonders of Our Home—The Earth", Vol. DE, pp. 172-190.

*16 mm. Sound Films**Ontario Visual Education Branch*

- Day and Night (SG-34)
- Earth in Motion (SG-30)
- Earth and Its Seasons (SG-4)
- Earth's Rotation and Revolution (SG-6)
- Latitude and Longitude (SG-14)
- The World We Live In (SG-49)

National Film Board of Canada

- The Earth As a Planet

Ontario Department of Lands and Forests

- Four Seasons (colour)
- Eskimo Summer
- The Sun—Friend or Enemy (colour)

Ryerson Film Service, Toronto

- What Makes Day and Night?
- What Causes the Seasons?

*Film Strips**Ryerson Film Service*

- Why the Seasons?

General Films Limited, Toronto

- Our Earth in Motion (colour)

18

DISCOVERING NEW WORLDS

When I consider Thy heavens, the work of Thy fingers,
The moon and the stars, which Thou hast ordained;
What is man that Thou art mindful of him!

Psalm 8: 3

THE SKY, with its many kinds of lights, must have appeared mysterious to our ancestors. They must have wondered what the moon was and why it kept changing in shape and in position in the sky, what were the twinkling spots of light we call stars, and what was happening when a meteor streaked across the sky. Not until the invention of the telescope was man able to answer such questions.

The Solar System

The solar system, the system of the sun, derives its name from Sol, the Roman sun god. It is composed of the sun in the centre, the planets surrounding it, and their many moons.

The Sun's Planet Family.

PUPIL INVESTIGATIONS. *Look for planets.*

On a bright night, notice the stars shining with a twinkling light. Look for one or more bright, star-like objects that do not twinkle. Careful observation on successive evenings will show that these objects move among the stars. Each of these steadily shining bodies is called a planet (from the Greek word for wanderer). The planet best known to us is our earth.



To get a better view of the planets, imagine that we are a thousand million miles above the earth. From our point of observation we would see the earth and its eight sister planets traveling round the sun in nearly circular courses, called orbits. The planets have no light of their own and, therefore, cannot twinkle like stars. They are visible to us only because they are lighted by the sun. Two of the planets, Mercury and Venus, are always closer than the earth to the sun. The six others are farther away.

Fig. 18-1 shows the names and the comparative sizes of all the planets; fig. 18-2 shows their comparative distances from the sun. To remember their names in the correct order, from the sun outwards, memorize this sentence: "M-an V-ery E-arly M-ade J-ars S-tand U-p N-early P-erpendicularly." The first letter of each word is also the first letter of the name of a planet.

Things To Do

1. Have a planet march. Select pupils to represent the sun and the four inner planets, giving attention to size. In the schoolyard, select a central spot for the sun. Use a string to make circles of radii $3\frac{1}{3}$ feet, 6 feet, 8 feet, and 12 feet round the sun to represent the orbits of Mercury, Venus, Earth, and Mars. The pupils selected should march on these four orbits at a speed requiring exactly 6, 15, 24, and 44 seconds respectively to go round the centre.

2. Represent the planets in size and distance as follows: the sun, a 2-foot circle of newspaper; Mercury, a radish seed at 31 yards from the sun; Venus, a small pea at 52 yards; Earth, a pea at 71 yards; Mars, a large radish seed at 108 yards; Jupiter, an orange at 372 yards.

FIG. 18-1. THE COMPARATIVE SIZES OF THE PLANETS.

The Movements of the Planets. All planets travel round the sun, each on its own nearly circular path, called its orbit. They move along at different speeds, taking different lengths of time to make a complete trip round the sun. Therefore, each planet has its own particular length of year. Like the earth, each of the planets turns round and round on an imaginary axis. The half of the planet towards the sun has day while the half facing away from the sun has night. Because each planet turns at a different rate, each has its own peculiar length of day—not 24 hours, as the earth has.

The planets travel round the sun in nearly circular paths. What keeps them on their courses? An experiment will help us to answer this.

EXPERIMENT 18-1. *To illustrate why planets stay on their courses.*

Tie an elastic to a small ball. Swing the ball round and round at a uniform rate. Why does the ball stretch the elastic? Because the inward pull of the elastic is equal to the outward pull of the ball, the swinging ball continues to travel in the same circle. If there were no air to hinder the ball's motion, it would travel forever in this circle at the same speed.

The sun pulls all objects towards it with an enormous force of gravity. This great attraction — enough to make a 135-pound man weigh about two tons at the surface of the sun, if he could exist there — constantly pulls all the planets towards the sun as the elastic pulled the ball towards your hand. Because the inward pull of the sun on each planet is equal to the outward pull of the revolving planet itself, the planet continues to move in the same circle.

FIG. 18-2. THE COMPARATIVE DISTANCES OF THE PLANETS FROM THE SUN.



Some Planets Are "Morning and Evening Stars". At certain times of the year a very bright light that does not twinkle is seen low in the western sky just after sunset. This "evening star" is the planet Venus, twin to Earth in size. When Venus is seen just before sunrise, it is called the "morning star". Because Venus is relatively close to the sun, the two are always seen in the same part of the sky. The planet Mercury, also called a morning or evening star, is seldom seen because of its closeness to the much brighter sun.

The More Distant Planets. Next to Venus in brilliance is our largest planet, Jupiter, 1,300 times as big as the earth. Its yellowish white light is the brightest spot in the heavens after Venus sets. In keeping with its size, Jupiter has nine moons, of which four are visible through a field glass.

The second largest planet is Saturn, almost a twin to Jupiter, but much farther away. The three rings about Saturn interest us particularly. They have been shown to consist of swarms of tiny moons. Saturn's year equals thirty of ours because this planet takes 30 years to go round the sun.

Are there people on Earth's little neighbour, Mars? Perhaps not, although we do know that this planet, which appears to us like a reddish star, has an atmosphere like ours, and four seasons.

The remaining three planets, Uranus, Neptune, and Pluto, are so far away from us that they are not easily seen, and they are so far from the sun that they are very cold.

Ever Onward. Let us return to the distant point in space from which, in imagination, we saw the planets revolving round the sun, and the moons round the planets. Is the sun moving, too? Yes, it is racing forwards through an unlimited vacuum of space at more than 4,000 miles an hour—and, of course, the whole solar system, including the planets and their moons, move along with it. We on the earth know this to be true because the sun is constantly changing its position in relation to other stars.

The Moon

The greater light to rule the day, and the lesser light
to rule the night. Genesis 1:16

Note

The study of this topic should continue at regular intervals of two or three days beginning with the date of a new moon and continuing for two days past the date of the full moon. To make it easier to follow the activities suggested below, renumber the school calendar in red ink so that the date of new moon is "0", the next day "1" (meaning that the moon is one day old), and so on, until the date of the next new moon. This is a moon calendar, the kind used in the past by many peoples.

In earlier grades, and by our own observations, we have learned more about the moon than the ancients knew. As we watch the moon appear to change in shape from day to day through a month, we speak of new moon, first quarter, full moon, and fourth quarter. We know that the full moon, like the sun, appears to rise in the east and set in the west. We can understand now that this apparent motion is explained by the fact that we are always travelling towards the east on the rotating earth.

The moon is always travelling round the earth. The path it follows, called its orbit, is about 240,000 miles out from the earth. Although the moon is much closer than the sun to the earth, it would take us more than 16 full days to travel to the moon in a jet plane at a speed of 600 miles an hour. The moon itself takes $27 \frac{1}{3}$ days to complete its journey round the earth.

The moon differs from the sun and stars in that it does not have any light of its own. We see the moon only because the sun lights it. Because the sun can light only half of the moon at once, we can see only the part that is both lighted and facing towards us. We are about to discover how this explains the phases of the moon.

The Phases of the Moon. A series of observations, carefully planned and carried through, would help us to understand the hows and whys of the changes we see in the moon.

The Growing Moon.

PUPIL INVESTIGATIONS. *Observe the changes in the shape and the position of the growing moon.*

1. Look for the moon immediately after dark the night of a *new moon* and the next night. Observe the shape and the position of the moon in the sky at the same hour every clear night thereafter for 2 weeks.

Copy figure 18-3 in your notebook. Using your moon calendar, fill in the age of each phase of the moon. Colour the lighter portions yellow and the shaded parts black.

2. Can you see the moon the night of a new moon? Do the points of the crescent moon point towards or away from the sun? What is the shape of the moon when it is 7 days old? Why is this called *first quarter*? On what day do you see the *full moon*? At what time does the full moon rise? Where?

3. Refer to figures 18-4 and 18-5 as you study the following paragraphs.

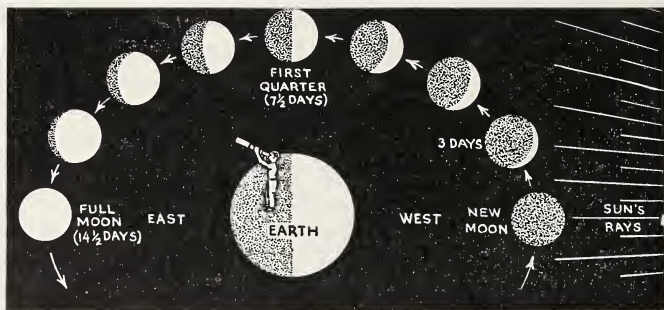


FIG. 18-3. OBSERVING THE GROWING MOON.

New moon occurs when the moon is between the sun and the earth. While in this position for one night, the lighted side of the moon is away from us, and the dark side is invisible, so we see no moon. A day later, the moon has moved far enough out of line with the sun to permit us to see a narrow crescent of the lighted

half of the moon. This we see in early evening in the western sky. The points of the crescent are turned away from the sun.

First quarter is reached when the moon is seven days old. We call this phase of the moon first quarter for two reasons: first, the moon has completed the first quarter of its journey round the earth (fig. 18-5); second, we see only a half of the lighted half

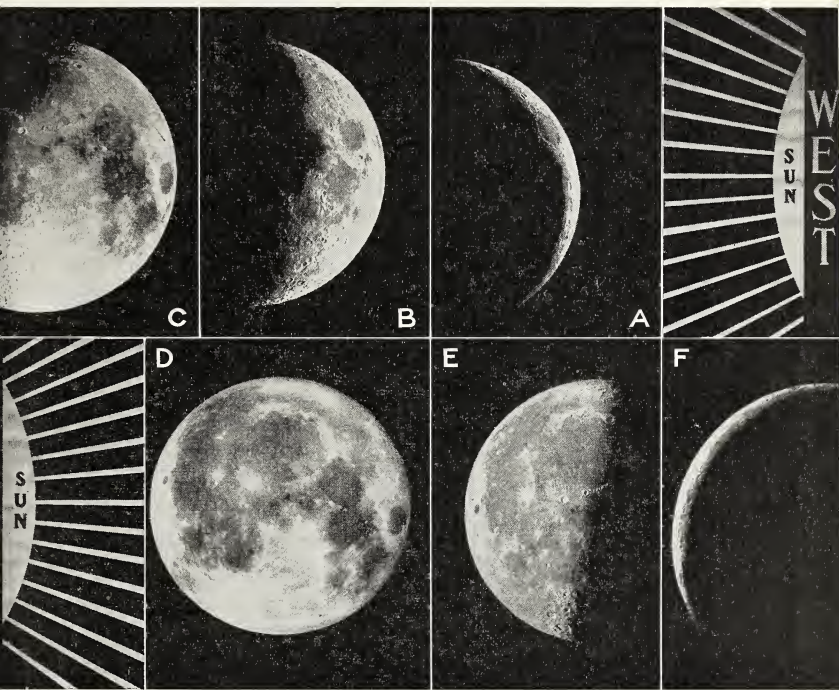


FIG. 18-4. SOME PHASES OF THE MOON.

A, the new crescent of the moon 3.85 days after new moon. It is seen in the western sky just after sunset. B, the moon, 5 days old, showing a larger crescent. C, the moon when 9.75 days old, just past first quarter. D, 16 days old and just past full moon, as shown by the irregular margin at the right. E, the waning moon, $22\frac{1}{2}$ days old. The shadows in its craters show that the sun is shining on it from our left. F, the moon, 27 days old. Only a small crescent of its lighted side is visible to us.

of the moon, a quarter of the moon. When the moon is at first quarter, it becomes visible to us in the south in the evening. From the seventh day to the fourteenth day, more and more of the lighted half of the moon becomes visible to us.

By the time of *full moon*, the moon has completed half of its journey round the earth. It is now on the side of the earth opposite the sun and has its lighted half all turned towards us and, therefore, visible (fig. 18-5). The full moon rises in the east at sunset and is visible all night. It appears to move across the sky and to set in the west in the morning.

The Waning Moon.

PUPIL INVESTIGATIONS. *How does the waning moon change in shape and position?*

Observe the shape of the moon and its time of rising in the east the next two evenings after full moon. Which side of the moon remains a complete half circle? Which side becomes invisible? Compare these observations with those before the moon became full. Study fig. 18-4 and fig. 18-5.

The moon rises a little later each evening after full moon. During this third week of its journey round the earth, the moon has less and less of its lighted half turned towards us. By the 21st day, the moon has travelled three-quarters of the way round the earth (fig. 18-5). We again see only half of its lighted half, a quarter of the moon. For these reasons, we call this phase of the moon the *third quarter* or the *last quarter*.

In the week after the third quarter, the moon wanes still further. Soon, only a crescent of the lighted half is towards us and visible. The moon completes its journey round the earth on the 29th day and again comes between us and the sun. Again the moon becomes invisible to us because its lighted side is turned away from us. Thus, the moon moves onward on its orbit round the earth and becomes visible again as the young moon of the next moon month.

These apparent changes in the shape of the moon continue daily. Because there are four stages in which we can accurately

describe the moon's shape and position, we speak of the four phases of the moon, namely, new moon, first quarter, full moon, and third quarter.

The Moon's Apparent and Real Movements. We have learned now that the moon *appears* to move from east to west each night, and that the cause of this apparent motion is the earth's rotation from west to east.

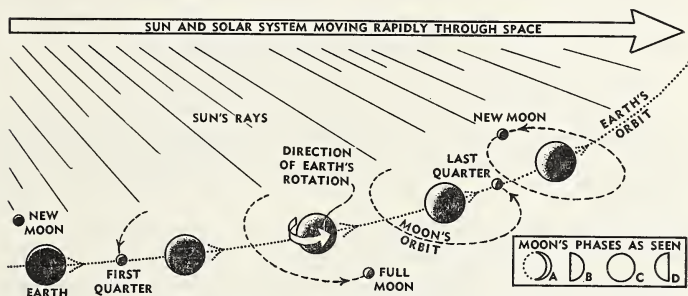


FIG. 18-5. REVIEW THE MOVEMENTS OF THE MOON.

This drawing illustrates the moon revolving round the earth once in $29\frac{1}{2}$ days while the earth moves forwards on its orbit about one-thirteenth of the distance round the sun. Notice the rays of light from the distant sun shining on both the earth and the moon.

At *new moon*, we face the dark side of the moon, but we see a small crescent (A) the next night. At *first quarter*, the moon has moved far enough round on its orbit that we can see half of the lighted half of the moon (B), really one-quarter of the whole moon. At *full moon*, the lighted half of the moon faces the earth, and we see a full circle (C). At *last quarter*, the moon has travelled three-quarters of the way on its orbit round the earth, and we again see half of the lighted half (D), namely one-quarter of the moon. In the fifth drawing, the moon is shown as having completed its journey round the earth, back again to the position of new moon.

The white arrow on the central drawing of the earth shows the direction of the earth's rotation. The moon rotates on its axis in a similar manner.

The large arrow at the top of the drawing illustrates the continual movement of the sun, its planets, and their moons forwards through space.

Thus we see that the moon has four movements: (1) its revolution on its orbit round the earth, (2) its movement forwards with the earth round the sun, (3) its rotation, and (4) its movement forwards through space with the whole solar system.

The moon has several real movements. First, it travels on its orbit round the earth once each $27 \frac{1}{3}$ days, producing the phases we see. Second, the moon is carried by the earth round the sun and, because of this, the moon appears to us to have taken $29\frac{1}{2}$ days, as shown on our calendars, to complete its revolution round the earth.

Third, the moon rotates on its axis as the earth does. Because the moon takes the same length of time to rotate once on its axis as it does to revolve round the earth, we always see the same side of the moon. For this reason, the figure that we often refer to as the "man in the moon" is always visible to us.

A fourth real movement of the moon is shown in fig. 18-5.

To review all the real movements of the moon, stop reading now and study carefully fig. 18-5 and the description that accompanies it.

The Nature of the Moon.

PUPIL INVESTIGATIONS. *Study the surface of the moon.*

Examine the moon with a pair of field glasses at first quarter and again at full moon. What causes the dark shadows seen at first quarter (fig. 18-4)? What makes up the "man in the moon" at full moon?

Although the moon has a diameter of only one four-hundredth of that of the sun, it appears to be about the same size. This is so because the moon is only about 240,000 miles from us, about one four-hundredth of our distance from the sun. Because the moon is so close, our telescopes have enabled us to observe much about its surface—its rugged mountains thousands of feet high and its deep craters many miles across. In figure 18-4,C we can see large, dark spots, called "seas"—really just plains on the moon which were first seen by Galileo through his simple telescope. Our photograph was taken through a modern high-powered telescope and, in addition to the plains, shows the craters as small, circular markings with the sun's shadow visible as a dark margin at the right in each.

The moon is an airless, dreary, desolate world. Because it has no atmosphere, there can be neither sound nor water on it. Without water, it cannot have soil, or plants, or other life. Because a

day on the moon equals about twenty-nine of our days, the sun's rays, unhampered by clouds and atmosphere, beat continually upon each place for nearly two weeks. This constant sunshine raises the temperature of the moon's surface far above the boiling point, while in the shadow of a nearby crater the temperature is about 182 Fahrenheit degrees below zero (-182°F.). Little wonder the moon is a dead world!

Beyond the Solar System

"To know night's goodly company of stars
And those bright lords that deck the firmament."

For ages, man has studied the stars. Even ancient peoples knew where certain stars could be seen. The Phoenicians used the stars to guide their ships throughout the Mediterranean Sea, and Columbus used them to chart his course to and from a new continent. With the knowledge gained by ages of careful observations, early peoples made maps of the sky for different seasons. However, until the invention of the telescope, astronomers knew little about what the stars were really like or how far away they were.

The Dipper and the North Star. The *North Star* is one of the most useful to man. Because it shows the true north more accurately than a compass needle, it is a safe guide. Because it is so bright, it is an easily followed guide.

PUPIL INVESTIGATIONS. *Look for the Big Dipper and the North Star.*

On a clear night find the *Big Dipper*, recognized by its shape, its seven stars, and its location in the northern sky. Fig. 18-6,A will help you. Use a strong flashlight that gives a narrow beam of light to trace directions in the sky. Point the beam of light towards the two stars in the dipper farthest from its handle (the pointer stars). Keep the beam moving along in line with these stars from the top of the *Big Dipper* to about five times the distance between them. The bright star found in this way is the *North Star*, also called *Polaris* or *Pole Star* because it is vertically over the North Pole.

The *North Star* forms the end of the handle of the *Little Dipper*.

Find this group of seven stars facing towards the Big Dipper. Because the two dippers face each other, they are said to pour into each other.

Other Stars and Constellations. On a clear night in the country, where no other lights interfere with our view of the sky, a few stars are seen in early evening. These are the brightest ones. As the night grows darker, less brilliant stars become visible until we can see about 3,000. Many millions of stars may be seen through a modern telescope.

Over the centuries, stories have been told about the stars and the constellations. The word constellation means a group of stars

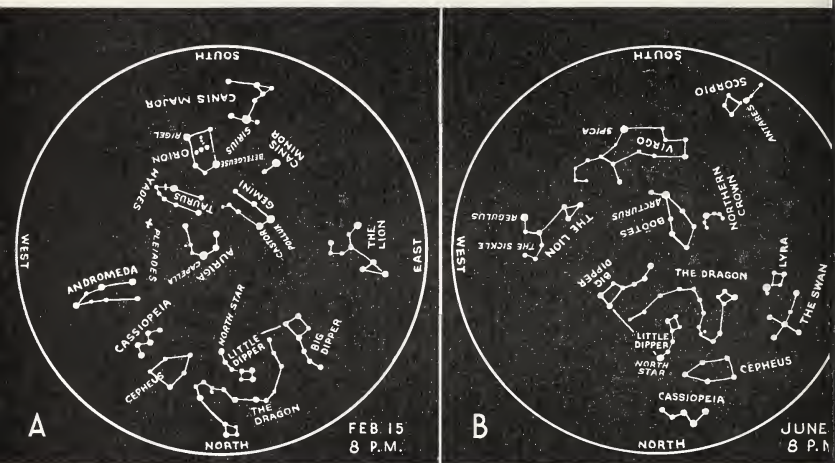


FIG 18-6. STAR MAPS FOR FEBRUARY AND JUNE.

The following suggestions will help you to use these star maps:

- (1) When facing north, hold the map with the word "north" downwards—and follow similar instructions when facing south, east, and west.
- (2) If you use either star map before the date indicated on it, you should change the time of observation to one hour later than 8 p.m. for each half month earlier than the date shown, also to one hour earlier than 8 p.m. for each half month later than the date shown.
- (3) For convenient outdoor use, you may wish to make larger copies of these star maps on heavy card.
- (4) A flashlight will be helpful both in reading the star maps and in pointing to stars.

(from *con*, together, and *stella*, star). One constellation was said to represent Hercules, the strong warrior; another Cassiopeia, an ancient queen. Still others were thought to represent such animals as the bear, the dog, and the horse.

PUPIL INVESTIGATIONS. *Find some other constellations.*

1. *Observations for February or March.* Use fig. 18-6,A to help you find other constellations and their names. Try to locate *Cassiopeia*, a group of five bright stars forming a W or an M in the northern sky. Near Cassiopeia is *Cepheus*, somewhat like a church spire pointing up to the North Star. When you have found these, search for *Draco*, the *Dragon*. Notice that this constellation is a long curved line of stars winding half way round the Little Dipper and turning back like a serpent. A cluster of stars marks its head.

Look straight ahead towards the south until you see three bright stars in a row, a part of the constellation, *Orion* (figs. 18-6,A and 18-7). These three bright stars are supposed to belong to the belt of a great hunter who bears a big club in his right hand. To the south-west of the three stars is another very bright star, *Rigel*, which marks the hunter's knee. Opposite this, to the north-east of the belt, at the shoulder, is a very large red star, *Betelgeuse*, several times larger than our sun, but very much farther away. Close on the heels of Orion come his two faithful dogs, *Canis Major* and *Canis Minor*. In the nose of the former is the bright dog-star, *Sirius*.

2. *Observations for June* (fig. 18-6,B). By following along the handle of the Big Dipper, then twice as far again in the same curve, we reach *Arcturus*, the bright orange star that forms the tip of the kite-shaped constellation, *Bootes*, the *Bear-driver*. If we continue from Arcturus along the same curve and for the same distance as before, we see a brilliant, bluish-white star, *Spica*, in the constellation *Virgo*, the *Virgin*.

East of Bootes is *Corona*, the *Northern Crown*, a semi-circle of stars open towards the north.

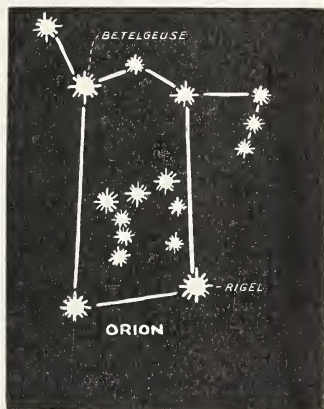


FIG. 18-7.

To the south-east of Corona is *Scorpio*, the most brilliant summer constellation. Because *Scorpio* is never visible at the same time as the hunter, *Orion*, we have the legend that *Scorpio* was given a place in the heavens because he conquered the mighty hunter with his sting. The fiery star, *Antares*, in *Scorpio*, is the largest known star, with a diameter more than 400 times that of the sun. If *Antares* were as close as the sun to us, it would appear 1,500 times as brilliant.

In the western sky find the constellation, *Leo*, the *Lion*, which includes the *Sickle*, with the bright star, *Regulus*, at the end of the handle.

How Far Away Are the Stars? The sun is really a star. If all the stars were as close to us as the sun is, they would look like the sun; many stars would appear even larger and brighter. But the nearest star beyond the sun is a very long distance away. An aeroplane travelling at 100 miles an hour could travel to the moon in about 100 days, or to the sun in 106 years—but it would take about 24,000,000 years to reach the nearest star beyond the sun.

Light takes time to travel to us from a star. We learned in chapter 17 that light travels 186,000 miles, seven times around the earth, in one second. The distance that light travels in a year is called a light-year and equals about 6 million million miles. The light from the nearest star beyond the sun requires 4.3 years to reach us; it is 4.3 light-years away. How many miles is this?

The bright star, *Arcturus*, in the constellation, *Bootes*, is so far away that the light that we now see from it left it 40 years ago.



FIG. 18-8. DAVID DUNLAP OBSERVATORY AT RICHMOND HILL, ONTARIO.

Left, the dome, the top of which opens to permit the huge telescope within to be pointed to any part of the sky. Right, the administration building with three domes that open when the smaller telescopes within are used.

Some of the fainter stars are so far distant that light that started from them when Champlain was exploring Eastern Canada is just becoming visible to us now. These stars have been studied by means of powerful telescopes housed in observatories.

Stars Differ in Colour and Brightness. Some stars appear brighter than others because they are closer to us. Others appear brighter because of their large size, perhaps millions of times larger than our sun. Still others seem particularly bright because they are so hot.

Stars that appear white or bluish are much hotter than those that appear yellow. Yellowish stars are about as hot as the sun. Reddish stars are the coolest.

The Stars Only Seem To Move. Like the sun and the moon, stars seem to rise in the east and set in the west. This is an illusion. As we are carried onward by the rotating earth, the stars above us are left behind. Because we move from west to east, the stars seem to rise in the east, move from east to west, and set in the west.

For the same reason, the Big Dipper and the whole northern sky seem to rotate round the North Star as the evening and the night pass. In 23 hours and 56 minutes these stars seem to pass through a complete circle. This change of position of the Big Dipper and its neighbouring constellations enables us to use them as a clock to tell us both the hours of the day and the months of the year.

Something To Do

With thick, white poster paint, mark the Pole Star on the inside of an old umbrella where the stem goes through it. In their proper places around this, paint the constellations mentioned above. Now, turn the umbrella the way the stars in the northern sky appear to move.

Some stars visible to us in summer cannot be seen in winter. Similarly, we can see some stars in winter that we cannot see in summer. As the earth makes its annual revolution round the sun, it is constantly carrying us into other parts of the heavens and within view of different stars.

The Milky Way

Many things Nokomis taught him
Of the stars that shine in heaven . . .
Showed the broad white road in heaven,
Pathway of the ghosts, the shadows. . . .

Longfellow—"The Song of Hiawatha"

PUPIL INVESTIGATIONS. *Find the Milky Way.*

On a clear night when the moon is not visible, look for a misty, irregular path of light across the sky. This is the *Milky Way*. Through what constellations does it pass? Examine it with field glasses. Of what is it composed?

To the Chinese, the Milky Way was a river in the sky with silver fish in it. The American Indians thought it was a cloud of dust kicked up by a horse and a racing buffalo. The Algonquin Indians looked upon it as the path over which the souls of the dead travelled to the Happy Hunting Ground. The telescope has shown us that the Milky Way is made up of millions of distant stars forming a disc, something like a plate on edge, with the solar system in the middle.

Meteors and Comets

Meteors. What we often call "shooting stars" or "falling stars" are not stars at all; they are meteors. On some evenings in summer we may see a meteor every few minutes. The Babylonians thought these meteors were real stars falling out of the earth's ceiling. Meteors are made up of iron, nickel, or rock, or all of these. As they travel rapidly through the air surrounding the earth, they become so hot that they shine brightly. This heat is caused by the friction of air, somewhat as heat is produced by friction when you rub your hand rapidly over your coat sleeve. Owing to the increased resistance of the air nearer the earth, meteors usually break up into small pieces when they are fifty or sixty miles from the earth, and the moving light disappears.

Sometimes remains of a meteor reach the earth. The mass of

rock is then called a meteorite. In Arizona there is a great crater 4,000 feet across and 600 feet deep caused by a meteorite crashing into our earth.

Comets. Planets are not the only heavenly bodies that travel round the sun. Other bright heavenly objects, smaller than the moon and with long trailing tails, travel great distances through space directly towards the sun, pass close around it, then whirl away from it again. These are comets. The path of a comet is a long, narrow curve with the sun appearing to be inside one end of it. A comet usually takes many years to complete its journey. Halley's comet (fig. 18-9) is visible to us only once every 76 years, and will not be within sight of the earth again until 1986. This is because these bright objects are visible only when they are on the part of their path quite close to the sun.



FIG. 18-9. HALLEY'S COMET.

The head and tail of the comet are clearly visible while the comet moves for several nights across the sky. Comets always have the head towards the sun whether they are approaching or retreating.

Ancient peoples believed that comets were sent by angry gods to destroy the earth. The sight of a comet, therefore, caused great fear.

Things to Do

1. Make a class scrapbook of star maps and of pictures of the planets, the moon, eclipses, stars and constellations, the Milky Way, meteors, and comets. Include poems and newspaper articles.
2. Visit a planetarium or an observatory if possible and look through a telescope at some distant heavenly bodies.

3. With the help of star maps, practise drawing several constellations. As soon as you can draw one from memory, go out and look for it. Then draw the constellation again as you saw it in the sky.

4. Describe how planets differ from stars in these respects: size, temperature, light, movement, and twinkling.

5. Study fig. 18-10 as a partial review of this chapter.

Things To Explain

1. Why planets do not twinkle.
2. Why the same stars are not visible in each season.
3. Why a star or a constellation is not seen in the same part of the sky all through the night.
4. Why we always see the same side of the moon.
5. Why a meteor usually disappears before reaching the earth.
6. Why we do not feel warmth from stars, though many of them are hotter than our sun.
7. Why stars are of different colours.
8. What a *light-year* is.
9. In what way moonlight is really sunlight.
10. Why we cannot see the new moon.
11. Why it is unlikely that people will ever visit the moon.
12. What kinds of heavenly bodies make up the solar system.

A Test

Select the answer that completes correctly each of the following:

Sample: The sun is (1) all solid rock, (2) a body of very hot gases, (3) a planet, (4) about ten times as large as the earth. (Number 2 is the correct answer.)

1. Planets give light because (1) they are so hot, (2) they reflect the sun's light, (3) they are white in colour, (4) they are made of very hot gases.

2. The solar system consists of (1) all the known stars, (2) the planets and their moons, (3) the sun, the planets, and their moons, (4) all objects seen in the sky.

3. We can distinguish a planet by the fact that (1) it twinkles, (2) it is red, (3) people live on it, (4) it shines with a steady light.

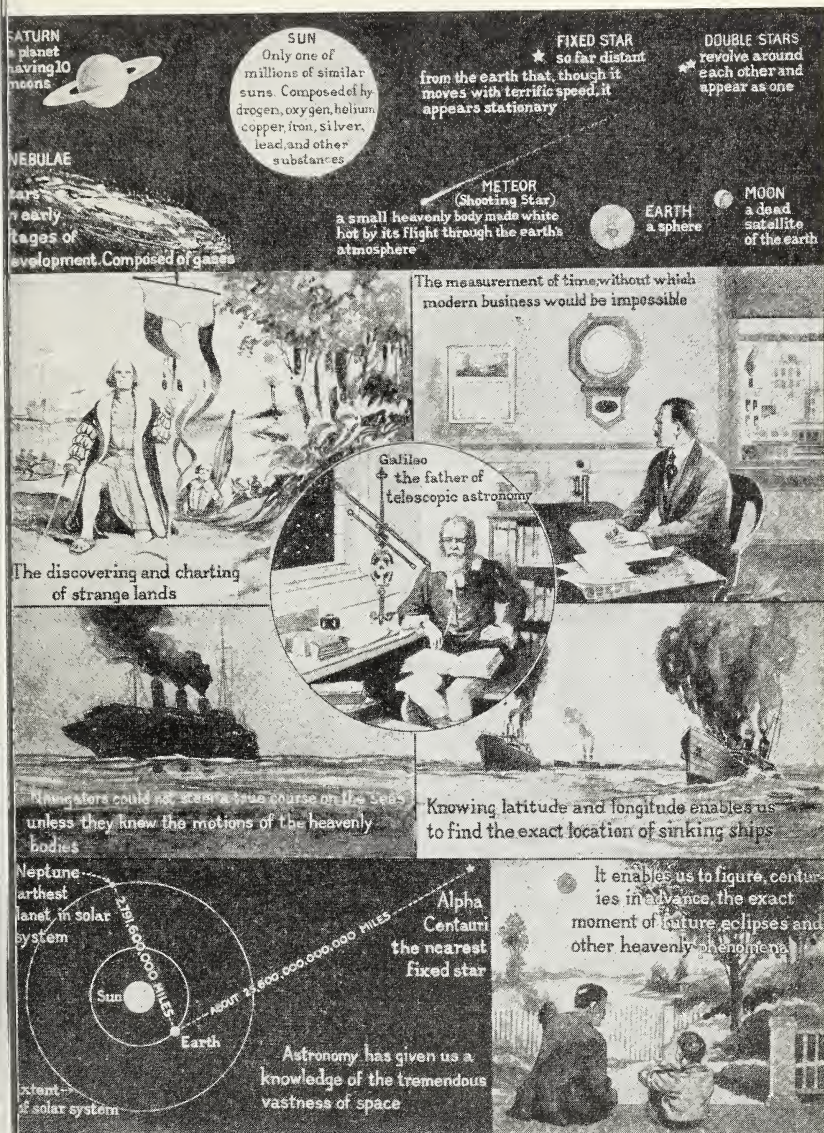


FIG. 18-10.

From Compton's Pictured Encyclopedia

Your Word List

Gravity, planet, comet, meteor, meteorite, light-year, solar system, vertical, perpendicularly, orbit, constellation

Read

Compton's Pictured Encyclopedia, 1953 Edition: "The Moon — Earth's Nearest Neighbour", Vol. M, pp. 382-388; "Astronomy—The Science of the Heavens", Vol. A, pp. 427-445; "The Nine Planets—Children of the Sun", Vol. P, pp. 281-285; "The Countless 'Suns' That Dot the Heavens" (many coloured plates), Vol. S, pp. 370-382; "Comet", Vol. C, pp. 420; "Meteors and Meteorites", Vol. M, pp. 180-182; "How Men Navigate over Seas and in the Air", "Navigating by Sun and Stars", Vol. NO, pp. 72-80.

16 mm. Sound Films

Ontario Visual Education Branch

The Sun's Family (SG-51)

Ryerson Film Service, Toronto

This Is the Moon

UNIT EIGHT

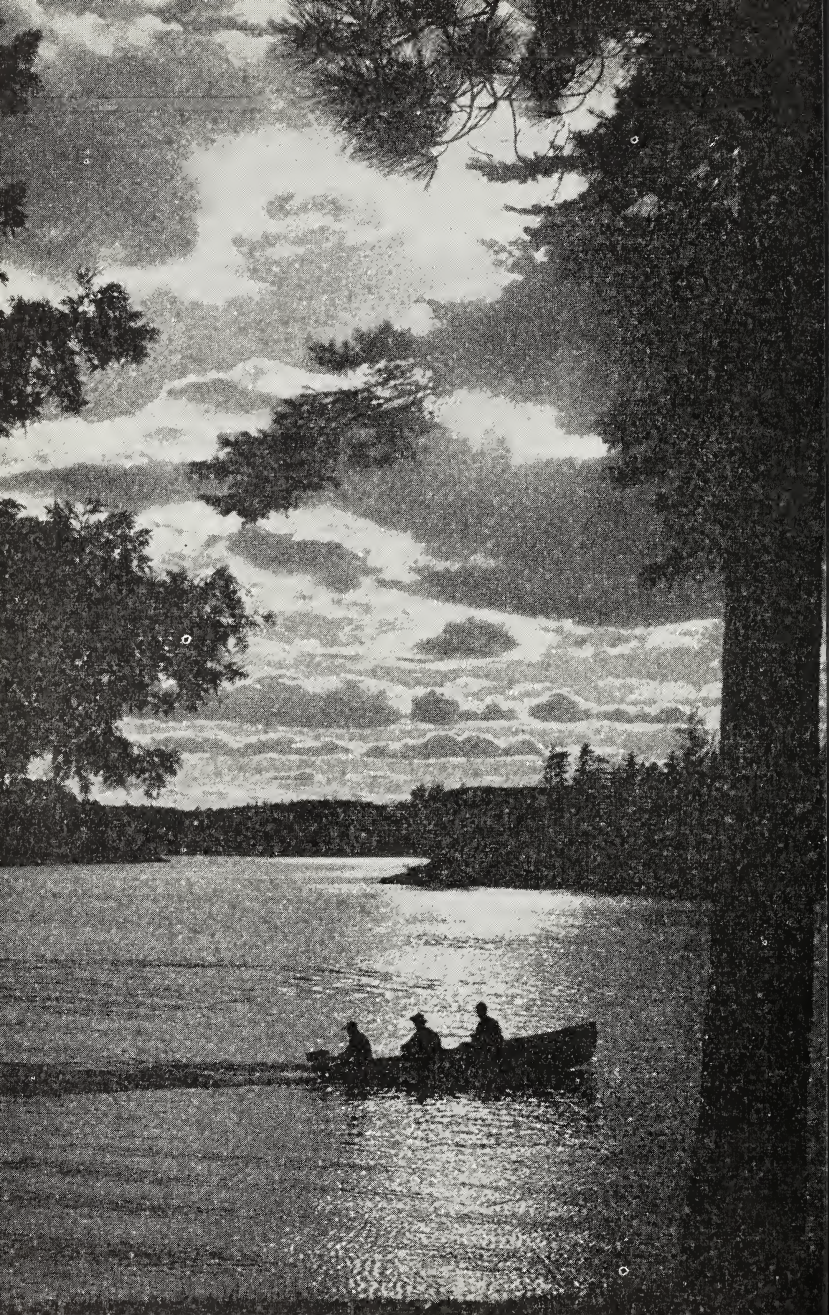
Let's Talk about the Weather

19. *WHAT MAKES THE WEATHER?*

The expression "as changeable as the weather" is appropriate, for most of the things that make up weather—temperature, wind or calm, clearness or cloudiness—are constantly changing. The sun's heat determines weather to a large extent: it heats the soil and, therefore, the atmosphere; it causes winds; and it evaporates moisture, causing clouds. By observing and recording weather conditions, we learn how to forecast the weather.

20. *WEATHER IN DAILY LIVING*

The frequency with which weather is a topic of conversation illustrates its importance in everyday living. Weather determines our comfort and our clothing. Weather conditions throughout the year determine how we build our homes to make them comfortable and healthful. Weather influences our means of travel and, sometimes, our methods of communication. Weather is important to plants and to animals, and, therefore, it is especially important to the farmer. How grateful we should be for daily weather forecasts.



19

WHAT MAKES THE WEATHER?

WEATHER HAS ALWAYS BEEN IMPORTANT to man. He varies his plans with clear skies and storms, with calm and wind, with heat and cold. These are conditions of the atmosphere, that huge sea of air in which we live. In this modern air age we need to understand much about the clouds and air currents and the general conditions of the atmosphere far above us. As a result, the study of weather, known as meteorology, has become the life work of numerous scientists, known as meteorologists, from pole to pole.

The word weather has a meaning different from that of the word climate. Weather is the condition of the air at a certain time and place with respect to temperature, pressure, moisture, and movement. When we speak of climate, we are talking about the average of all weather conditions over the years in a large area. A place with a cold climate may have its hot days, and a place with a dry climate may have its rainy season.

Weather Is Constantly Changing

Weather changes so often and in so many ways that special terms are necessary to describe both the weather and its changes.

Terms Used To Describe Weather. Temperature is described in degrees Fahrenheit above or below zero, or above or below freezing point. The terms hot, cold, and moderate are not reliable, for they have different meanings at different times

and places and with different people. We have learned that air pressure is measured in inches of mercury. It is described in general terms as high, low, steady, rising, or falling. We indicate the speed of the wind by the terms calm, light, gentle, moderate, fresh, strong, or gale. The meaning of each of these is given in the table on page 346. The sky may be described as clear, overcast, or cloudy, or may be further defined as hazy, cloudy bright, cloudy dull, or cloudy dark. Special names are given to distinctly different kinds of clouds. These are described on pages 353 to 355. Water condensed from the atmosphere may take the form of fog or cloud, dew or rain, sleet or hail, frost or snow. Rainfall is described as drizzle, slight, showery, steady, or heavy. Additional weather terms may be discovered by examining weather forecasts in the daily papers or by listening to them over the radio.

A School Weather Station. Accurate information about the weather is obtained at weather stations all across Canada by the use of special weather instruments. Much information of a similar nature can be obtained at your school or home by making and using some simple equipment.

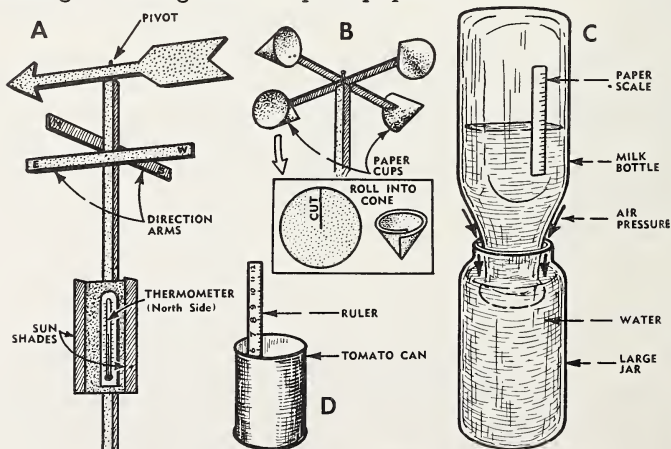


FIG. 19-1. YOUR WEATHER STATION.

A, a wind vane; B, a wind gauge; C, a water barometer; D, a rain gauge.

PUPIL INVESTIGATIONS. *Making and using a weather station.*

Use fig. 19-1 as a guide while carrying out the following investigations.

1. To tell the direction of the wind, make a wind vane (A) of metal or wood, pivoted so that it will turn freely on the top of a pole high enough to be clear of buildings and trees. The vane will turn so that it is parallel with the direction of the wind. After finding due south by using a compass or by observing the sun at noon, attach labelled direction pointers to the post beneath the wind vane. Attach a thermometer on the north side of the post, and shade it from the rays of the rising and setting sun.

2. To judge the strength or speed of the wind, make a wind gauge (B). Make paper cups in the manner shown in the inserted diagram. Make wooden arms at right angles to each other and support them as shown so that they are free to pivot on the top of a post. Fasten the paper cups crosswise on the ends of the wooden arms by means of thumb tacks.

3. To discover whether the air pressure is increasing or decreasing, make a water barometer (C). Put 3 or 4 inches of water into a milk bottle; then, with a paper held over its mouth, invert it in a jar almost full of water. Paste a vertical paper scale on the bottle. Mark the level of the water on the scale. A rise in level indicates increasing air pressure. You may use another barometer to graduate the paper scale.

NOTE

A water barometer is inaccurate because of the expansion and contraction of the air in the bottle caused by changes in temperature.

4. Make a rain gauge (D) to catch the rain and enable you to measure its depth. A deep, straight-sided vegetable tin such as that illustrated will serve well. Be sure to leave it where buildings or trees cannot interfere with the falling rain, also that you measure the depth of water in it immediately after the rain stops falling, before any of the water has had time to evaporate.

Making Weather Records. The first step in learning about weather is to observe from day to day all the factors of which it is composed. In this manner we can discover what causes weather to change and how we can foretell future changes.

Make a Weather Calendar

Rule a page in your science notebook as shown below. In the spaces, make a careful record of all factors that make up the weather. Continue to make observations and records for a month, or for a week at a time in different months of the year. Use the terms mentioned on pages 339 and 340. Obtain the required information by careful personal observations and from your school weather station.

Readings of air pressure and of other data that cannot be obtained at school or at home may be taken from the daily weather reports.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date							
Temperature 10 a.m.							
.....							
3 p.m.							
Air Pressure 10 a.m.							
.....							
3 p.m.							
Wind Direction							
Wind Strength							
Sky Appearance							
Clouds							
Rain, Snow, etc.							

Interpreting Weather Records. Every kind of weather is caused by something that happened in the weather before it. Rain is caused by clouds. Clouds are caused by evaporation of water. Evaporation is caused by heat. Cold may be caused by a north wind. When you have kept weather records for a month or for several weeks, you will be able to use them to express some simple weather rules that are usually quite reliable.

What Do Your Weather Records Teach You?

Study your weather records for a month or more and try to answer these questions:

1. Is the weather likely to be fair or rainy when the wind blows from the west? From the east?
2. What direction of wind usually brings cold weather? What direction, warm weather?
3. What kind of weather usually follows a rising barometer? A falling barometer?

We shall learn more about forecasting weather later in this chapter, when we have learned how temperature, air pressure, winds, and moisture affect weather.

Weather, Temperature, and Winds

How the Earth Is Warmed. Most of the heat of the earth's surface comes from the sun. Rocks and soil, through which the sun's rays cannot pass, become warmed by absorbing some of the sun's heat. This same heat then warms the atmosphere. You will understand better how this takes place if you perform the following experiment either at school or at home.

EXPERIMENT 19-1. *Do transparent objects absorb as much of the sun's heat as opaque objects do?*

Cover the glass of a pint sealer with paint or paper of a dark colour. Fill this sealer and an uncovered sealer with water, all at the same temperature. Place a thermometer in each sealer. Leave both sealers in the same place, exposed to strong sunlight. Read the temperature of the water in each sealer every hour. Make a table to record your readings. In which sealer does the water become warm faster? Which absorbs more of the sun's heat?

When the sun's rays struck the clear glass and the water, they passed through both. The rays that fell on the covered sealer could not pass through the covering material. This material absorbed the sun's heat and, by contact, warmed the glass. The warm glass heated the water.

The sun's rays give very little heat to the clear atmosphere as they pass through it to the earth. They give much heat to the rocks and earth, through which they cannot pass. The warm earth then heats the surrounding air by radiating the heat to it just as a hot stove or radiator radiates heat in a room.

Why Winds Blow. Now let us consider how the heat of the sun causes winds. You will recall how hot the sand on a beach becomes on a sunny day in summer. This hot sand heats the air above it, causing it to expand and, as a result, become lighter. At the same time the air above the nearby cool water remains cool and is, therefore, heavier than the warm air over the beach and the nearby land. As a result, the heavier, cooler air from over the water moves under the warmer, lighter air over the land and lifts it up. This horizontal movement of air from sea to land continues as a breeze or a light wind, known as a sea breeze.

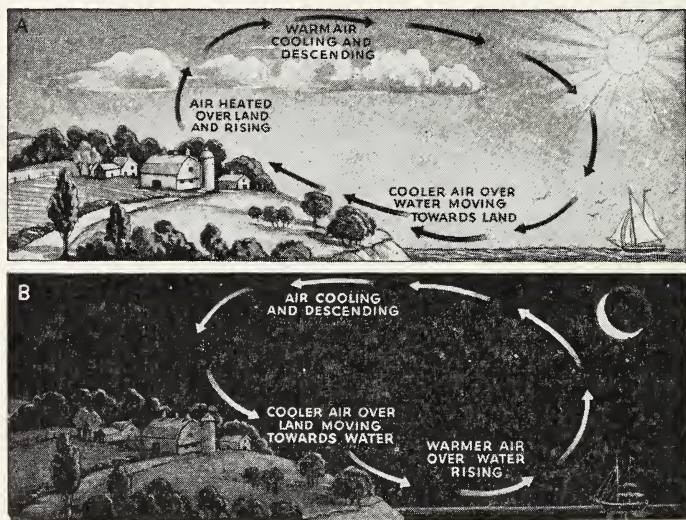


FIG. 19-2. SEA AND LAND BREEZES.

A. On a warm summer day a cool breeze, known as a sea breeze, often blows from over bodies of water onto the nearby land. There the air rises and circles back over the water again as shown in the drawing.

B. At night the air often moves in the opposite direction, as a land breeze, for then the air over the land is usually cooler than the air over the water.

At night, in warm weather, we often have a land breeze, a light wind blowing from the land to the sea. After sunset the

land receives no more heat from the sun, but it continues to radiate heat to the air. As a result, the land may become cooler than the nearby water. The air above the land then becomes cooler than the air above the water. The cooler air over the land then moves towards the water, pushing up the warmer, lighter air there just as the cooler sea air had pushed up the warmer land air during the day. The movement of air from the land to the water is a land breeze.

Meteorologists, people who study weather, speak of the wind as blowing from an area of high pressure towards an area of low pressure. This is what happens when land and sea breezes blow. When the air above the land becomes warmed and lighter than the air above the nearby water, the air pressure above the land becomes lower than the air pressure over the water. Therefore, the air moves as a wind from the area of higher pressure towards the area of lower pressure, or from the water towards the land.

Sometimes, however, the wind blows from a warm area towards a colder area, in the opposite direction to what we might expect. Let us consider why this happens. The air pressure in any particular place is determined by the total weight of all the air above that place. Therefore, the temperature of the air several miles above the earth's surface may play an important part in determining the air pressure at the earth's surface. In fact, the air around us may be quite cold although the air pressure where we live is lower than the air pressure at a warmer place a few miles away. Then a warm wind will blow from there towards us.

"Every wind has its weather." You can find out what kind of weather each wind brings.

PUPIL INVESTIGATIONS. *A wind chart.*

Keep a wind chart for 2 weeks, using the headings: *Date, Direction of Wind, Speed of Wind, Temperature, Air Pressure, Sky Condition.* Classify the speeds of winds according to the table on page 346. You will need this chart later when studying weather forecasting.

A Modified Beaufort Wind Scale

Terms Used in Weather Forecasting	Signs To Go By	Speed of Wind in Miles per Hour
Calm	Smoke goes straight up; flag not moving	Less than 1
Light	Smoke and wind-vane move; leaves flutter	1-7
Gentle	Flag blowing outwards; leaves moving freely	8-12
Moderate	Dust and paper move about, and small branches sway	13-18
Fresh	Small trees sway; white-caps form on water	19-24
Strong	Hard to walk, or to hold up an umbrella	25-38
Gale	Limbs of trees broken, or trees uprooted	39-63

The sudden and extreme heating of a region may cause a tornado. The air pressure in the heated area may become very low in comparison with the air pressure in the surrounding regions. As a result, the cooler, heavier air from the high-pressure areas will rush violently towards the low-pressure area in the form of a tornado. Its force may be great enough to crush buildings and uproot trees.

The area covered by wind may be small or large. The wind may blow over a rather small area, as a local sea breeze on a warm summer day. Elsewhere, the wind may blow inland from large areas of ocean water to the large land masses of a continent, or from polar regions towards places nearer to the equator.

Winds may help or hinder man in his daily work. In former days winds drove men's ships from continent to continent. Even today, wind power is used to drive windmills. Winds carry pure country air into cities and mix it with the impure air there. As the winds pass on, they may carry some of the city air to the country. Without winds, there would be no way by which

water vapour in the air above large bodies of water could be carried over land to fall as rain. Balanced against these useful effects of winds are the losses of life and the damages to property caused by gales, hurricanes, and tornadoes on land and sea. Thus, the heat of the sun and the ocean of air in which we live combine to produce winds that may either help or hinder us.

Weather and Moisture

Forms of Water in the Atmosphere. In chapter 9 we learned that air always contains some water vapour. We showed that water is constantly being *evaporated* from streams and other sources, becoming invisible in the air as vapour. The process by which liquid water changes to water vapour is called *evaporation* or *vapourization*. We learned, too, that water vapour can be condensed (changed back to liquid) by cooling. The process by which vapour changes to liquid is called *condensation*.

The amount of water vapour in air varies from time to time and from place to place. When all the water vapour possible is present in air, we say the air is *saturated*. Air is described as moist or *humid* when it contains a large percentage of all the water it can hold at that temperature; air is *dry* when it contains only a small percentage of this amount of moisture.

Much more water vapour can be present in warm air than in cold air. The air in a classroom at a temperature of 30°F. can contain only about three pints of water as water vapour. If this same air were heated to a temperature of 80°F., it would be very dry, for, at this temperature, from 12 to 15 pints of water could be present in the air as vapour. As warm, moist air becomes cooler, the amount of water vapour it can contain becomes less and less. A temperature may be reached at which some of the vapour must change back to liquid water by condensation.

Clouds, Fog, and Mist.

EXPERIMENT 19-2. *How is a cloud formed?*

Fill a milk bottle with hot water, then pour out all but an inch of the water. Place a piece of ice on the top of the bottle. Notice the cloud in the bottle. What caused the cloud to form?

The air in the bottle was laden with water vapour from the hot water. The ice suddenly cooled this air, making it incapable of holding as much water vapour as before. Some of the vapour had to condense. As this vapour condensed, it formed many droplets of liquid water, all so tiny that they floated in the air as a cloud.

Clouds in the atmosphere are formed somewhat as the cloud in the bottle was formed. On a warm summer morning the sun warms the soil and causes water to evaporate from it into the air. As the moist air is heated more by the warm soil, it expands, becomes lighter, and is forced upwards by the surrounding cooler air. At higher altitudes the warm, moist air becomes so cool that some of the water vapour in it condenses to form a cloud of tiny droplets of water floating in the air.

Fogs and mists are formed in much the same way as clouds. In low, swampy places, where the ground is cold, the air becomes cool enough at night to cause some of the water vapour in it to condense and form tiny droplets of water floating in the air. When closely packed together, these droplets become visible as a *fog*; when more widely scattered, they form a *mist*. A fog or a mist disappears when the sun evaporates the water droplets, or when the wind distributes them over a wider area.

Dew and Rain.

EXPERIMENT 19-3. *How are dew and rain formed?*

Thoroughly dry a tin can and put some ice in it. Watch the outside of the can become misty. Feel how wet it is. Watch drops of water form and run down the outside of the can. Where did the water come from?

The cool vessel caused some of the water vapour in the air close to it to condense. Tiny droplets of water, each invisible, formed on the cold metal as a mist. Then, as more and more water vapour condensed, these droplets of water became larger, visible, and so heavy that they rolled downwards.

Dew consists of drops of water on blades of grass or on leaves of other plants, also on fences and roofs. After sunset, objects on the earth's surface lose much of the heat they received from the sun during the day. As these objects become

cool, they, like the tin can, chill the air close to them and cause some of the moisture in it to condense and form tiny droplets, and then visible drops, of water. This is dew.

Weather conditions determine how much dew forms. The more humid the air, and the cooler the grass and other objects, the more likely is much dew to form. Winds tend to prevent the formation of dew by keeping the air close to the grass mixed with warmer air farther away. Trees and clouds also help to prevent dew formation. They reduce the amount of heat radiated away from the earth, keeping the grass from cooling so much.

Raindrops form in a cloud much as the drops of water formed on the cold tin can. As the air in the cloud becomes cooler, more water vapour condenses on the droplets of water that make up the cloud. When these droplets become too heavy to float in the air, they fall as raindrops. At the same time other tiny droplets of water in the cloud may bump together, join, and also make drops of rain.

Raindrops from a cloud may never reach the earth. They may fall through warm air currents and evaporate again.

Frost and Snow.

EXPERIMENT 19-4. *How is frost formed?*

Partly fill a dry tin can with snow or ice mixed with salt. Pack the mixture tightly. Over

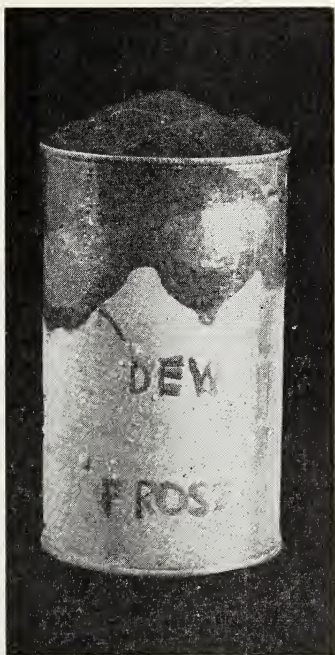


FIG. 19-3. THE FORMATION OF DEW AND FROST.

The mixture of snow and salt in the can has a temperature several degrees below freezing point. The labels on the can were made by writing through the layer of frost.

the mixture, place an insulating layer of cotton batting or crumpled newspaper. Observe what happens on the outer surface of the can. What forms there? Scrape off some of the frost. Does more form? Look for dew near the top of the can. What caused the little masses of ice to form?

If little frost forms, repeat the experiment a few feet from the steam escaping from a kettle.

Water vapour cannot, except under special conditions, change into liquid water below the freezing point; it changes directly from its invisible form to tiny crystals of ice. On cool plants or on windows, these crystals form as frost.

PUPIL INVESTIGATIONS. *What are snowflakes?*

Use a hand lens to observe snowflakes as they fall onto a cold object such as an outside window ledge or a cold, dark piece of cloth. Sketch several flakes. How many points has each? Do all the points of a flake look alike? Examine the tiny crystals that make up each flake. There are so many ways in which the thousands of crystals in a snowflake may fit together that no two flakes ever look alike.

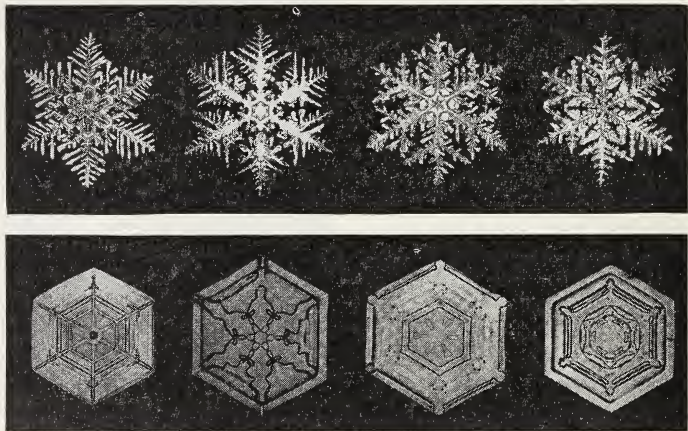


FIG. 19-4. VARIOUS FORMS OF SNOWFLAKES.

The upper row shows photographs of large, fluffy flakes with six feathery rays extending from a tiny crystal in the centre. These flakes usually fall when the temperature is slightly below freezing point. The lower photographs show flakes that are not feathery, but do have the characteristic six sides or points. These fall in very cold weather.

When clouds are high enough or cold enough, they consist of ice crystals instead of water droplets. These crystals float earthwards unless upward-moving air currents prevent them from doing so. The air through which the crystals fall may gradually become so cold that not all of the moisture in it can remain as water vapour. Some of this vapour will then change to ice crystals which become attached to the falling crystals. As more and more ice crystals become attached to each other, a snowflake forms and grows bigger.

EXPERIMENT 19-5. *Find out how much snow, when melted, equals 1 inch of rain.*

Turn a straight-sided pail upside down and insert it into level snow. Measure the depth of the snow beside the pail. Scrape away all the snow near the outside of the pail. After setting the pail upright, put into it all the snow that had been under it. Melt the snow in the pail, and measure the depth of the water. Now calculate the number of inches of snow necessary to produce 1 inch of water.

Sleet and Hail. In experiment 19-4 and fig. 19-3, showing the formation of frost, some drops of liquid water formed near the top of the tin can and ran downwards. When they reached the colder parts of the tin, they froze to form ice. In a similar manner, raindrops may freeze to particles of ice while falling. Then we have a sleet storm.

As a frozen raindrop falls, it may be stopped and carried upwards again by strong upward currents of air. If the same frozen raindrop moves upwards and downwards several times in this manner, it becomes coated with layer on layer of ice and snow and finally falls as a hailstone.

The Water Cycle. We have seen that water may exist as a solid, a liquid, or a gas. As a solid, water may be ice, frost, or snow; as a liquid, rain or cloud; and as a gas, invisible water vapour. It is constantly changing from one form to another—from vapour in the air to cloud and rain or to frost and snow; from snow and ice to water; then back again to vapour. This cycle of changes in water, back and forth from

form to form, is called the water cycle. The nature of the water cycle has been described more fully in *General Science*, Book I and is illustrated in fig. 19-5.

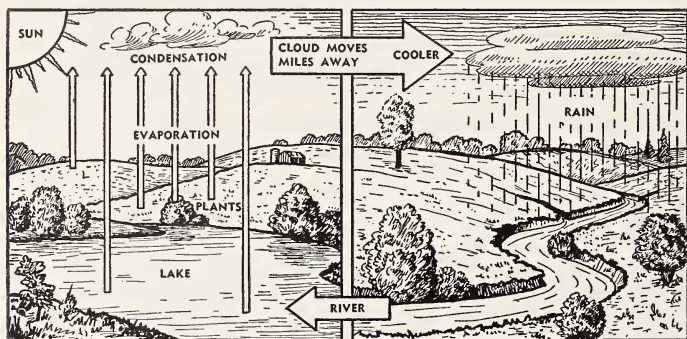


FIG. 19-5. THE WATER CYCLE.

A. Water evaporated from lakes and streams, from vegetation, and from the soil, with the help of the sun's heat and of air currents, rises as vapour, and condenses to form clouds in the cooler atmosphere at higher levels.

B. When the clouds have been carried some miles away, this same water falls as rain, forms little streams, then bigger ones, and flows back to its starting point.

Answer These

1. Why are summer resorts usually located near water?
2. Why do clouds sometimes disappear without rain falling?
3. Why should we not say "dew falls"?
4. What is meant by "the water cycle"?
5. How is sleet similar to, and different from, hail?
6. How is snow similar to, and different from, frost?
7. How are fogs and clouds similar and different?

Weather Forecasting

Accurate knowledge of how to forecast the weather is comparatively new. Although men throughout the ages studied the clouds and winds and learned some of the signs of rain, they had no way of making accurate weather forecasts, and no quick way of sending news of the weather to other places. America had been discovered more than a hundred years before men learned how to measure either temperature or air pressure.

Advances in science and in methods of sending news now enable meteorologists to foretell periods of heat or cold and of calm or storm a day or two before they arrive, and to warn people far and near of their coming.

Four times a day, several branches of the Dominion Meteorological Service assemble weather observations from centres throughout Canada. From each place, information is gathered concerning the air pressure, the highest and lowest temperatures, the direction and speed of the wind, humidity, clouds, visibility, and the amount of rain or snow that has fallen. This information is exchanged with branch offices of the United States Weather Bureau so that both countries can make more accurate forecasts. When all the information has been compiled, a weather map is prepared. From it, weather predictions are made for local areas.

Clouds Foretell Weather. To talk about different kinds of clouds, we must know their names. These are given in Latin so that they may be understood by peoples of all languages.

Some clouds are signposts clearly labelled "Fair Weather"; others give us a day or two of warning before they bring rain; still others produce rain at once.

The most common fair-weather clouds are *cumulus* clouds (cumulus—pile or heap). These are the clouds that drift like packs of wool or puffs of smoke low in the sky. Usually they have flattened bases and somewhat dome-shaped tops. Cumulus clouds that have tops like cauliflowers may be a sign of rain; those that have dark bases, and tops that reach up like anvils or clusters of towers or mountains, give rain immediately, as an April shower, a thunderstorm, or a "cloudburst". These rain clouds are called *cumulonimbus* clouds (nimbus—rain or storm). The approaching rain may be seen in the distance as a grey haze broken by darker, slanting streaks. At about the same time, comes the "calm before the storm", then a gust of wind—then the rain.

The change from fair weather to rainy weather usually requires a day or two. The coming of rainy weather is indicated

by a series of different kinds of clouds, each kind gradually changing into the next. First the clear sky is made hazy at great heights by curly *cirrus* clouds (*cirrus*—curl) like wisps of white hair spread in tufts, plumes, or bands across the sky. These clouds, usually two to seven miles above the earth, where it is too cold for the existence of water droplets, are composed entirely of ice crystals. By reflecting the sun's rays, they produce the red and orange colours that streak the western sky long after sunset, and the eastern sky before dawn.



FIG. 19-6. SOME COMMON KINDS OF CLOUDS.

A, fog; B, stratus clouds; C, altocumulus clouds; D, cirrus clouds; E, cirrostratus clouds; F, a cumulonimbus cloud (thunderhead), showing lightning coming from it.

The aeroplane is flying above the cloud level where flight is smooth; it would be "bumpy" among or below the altocumulus clouds.

On the high mountain, find: glaciers near the top, the elevations where only evergreen trees grow, and the region of deciduous trees nearer the base of the mountain.

As the wisps of cirrus clouds unite, they form a thin, whitish sheet or tangled web of *cirrostratus* clouds across the sky (stratus—spread out in a layer). Frequently these clouds produce a halo around the sun or the moon. Rain may then follow within a day.

The layers of clouds may thicken and darken until they completely hide the sun or moon. Such clouds are known as *altostratus* clouds. When rain falls from them, they are called *nimbostratus* (rain layer) clouds.

“So foul a sky clears not without a storm.”—Shakespeare

When the rain ceases and the clouds scatter, patches of sunlight become visible. Once again we may have the fair-weather cumulus clouds.

The Barometer Helps Us To Forecast Weather. Weather changes are usually preceded by changes in air pressure and, therefore, by changes in the reading on the barometer.

When the barometer “falls”, we know that the whole column of atmosphere above it is becoming lighter. Then, air currents are moving upwards, often producing clouds and rain. A slow, steady fall in pressure is generally followed by unsettled or wet weather; a

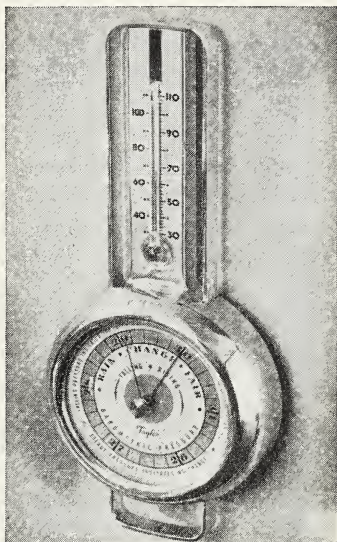


FIG. 19-7. AN ANEROID BAROMETER AND THERMOMETER.

What temperature is shown on the thermometer?

On the barometer, the numbers 26, 27, 28, 29, 30, and 31 indicate air pressures measured in inches of mercury, as would be shown on a mercury barometer (fig. 8-9).

The stationary hand at 29 was set there when the movable hand was at this point, to indicate any later change in air pressure. Since this stationary hand was set at 29, the measuring hand has moved up to 30, showing increasing air pressure (rising barometer reading) and, therefore, the likelihood of fair weather.

rapid fall is frequently followed by high winds and stormy weather.

When the barometer "rises", we know that the whole column of atmosphere above it is becoming heavier. Then, air currents are moving downwards. As they descend, they become warmer and, therefore, are capable of picking up more water vapour instead of losing some as rain. This is a sign of fair weather. A slow, steady rise in pressure usually brings settled, fair weather; a rapid rise in pressure is generally followed by strong winds and, later, by clearing weather.

Winds Help Us To Foretell Weather. The direction of the wind may be used, to a limited extent, to foretell weather. In Canada, south winds usually bring warmer weather; north or north-east winds, cooler weather. East of the Rocky Mountains, wind from the east, south-east, or north-east will probably bring rain or snow. When the wind blows from the west, the weather is likely to be clear.

Some Hints for Weather Forecasters

1. *Some signs of approaching stormy weather:* a rapidly falling barometer reading; winds shifting to the east; sky hazy with rapidly moving cirrus clouds; a halo (cirrus clouds) around the sun or moon; cumulus-type clouds with dark bases; smoke settling from chimneys towards the ground; absence of dew.

2. *Some signs of continued fair weather:* a high or slowly rising barometer reading; a breeze from the west; clear sky or white cumulus clouds; a cloudless sunset sky and a fair sunrise sky; heavy dew or morning fog.

3. *The weather is likely to clear when:* the barometer "rises"; wind changes to west; clouds break or become cumulus; the temperature falls suddenly.

4. *Temperature changes:* colder, if the wind shifts from east to north or from south to west; warmer, if the wind shifts to the south or if snow begins to fall.

Testing the Correctness of Weather Forecasts. The weather does not always follow exactly the forecasts made by the Meteorological Service. Some unexpected conditions may delay or modify the weather changes announced in a forecast.

PUPIL INVESTIGATIONS. *Testing official weather forecasts.*

Test the accuracy of the weather forecasts for at least 2 weeks by completing a chart like the one suggested below. If the forecast was nearly correct, leave the last column blank; if it was far wrong, state in what way.

Date	Newspaper Forecast	Actual Weather Conditions	Correction
April 10	Fresh winds; partly cloudy and cool; light showers in some districts	Moderate winds; cloudy in afternoon, and cooler; light showers	Winds less strong

PUPIL INVESTIGATIONS. *Making and testing your own weather forecasts.*

In your notebook, make a table like the one shown below for each of 3 or 4 days.

Read the barometer at intervals of a few hours to discover whether the air pressure is rising or falling. Find how the temperature is changing. Observe the direction of the wind and how it is changing, also the kinds of clouds visible. Record your observations in column 2 of the table.

Use the information given in this chapter, and that obtained from a study of your own weather calendar, to forecast tomorrow's weather. Write your forecast in column 3.

When tomorrow comes, describe the weather in column 4. Compare the actual weather conditions that existed then with those you forecasted. Correct your forecast in column 5. Try to discover why you were in error.

Date	Weather Observations	Weather Forecasted for Next Day	Actual Weather Conditions	Correction
	Change in Air Pressure	Winds.....		
	Change in Temperature	Temperature		
	Wind.....	Sky (clear, rainy, etc.)		
	Clouds.....		

Thunder and Lightning

Benjamin Franklin was, perhaps, the first man to suggest that lightning might be a form of electricity. To test his idea, he let a kite float into the clouds during a thunder storm while he held the wet string (a very dangerous thing to do!). How overjoyed he was when sparks came from the lower end of the wet string! He had proved that the flash of lightning was a current of electricity between a cloud and the earth.

You will recall our experiment, 14-1, in which we produced a flash of electricity from a pen or a comb, and by shuffling the feet across a rug. The electricity of lightning is produced in a similar manner. Air currents moving upwards through falling raindrops may break up the drops and cause some of the clouds containing them to be charged with electricity. As a result, powerful electric sparks may jump from one cloud to another, or from clouds to the earth. As they jump the space, these sparks become visible as flashes of lightning.

Lightning causes thunder. A lightning flash, one hundred thousand times as powerful as the electric current in our homes, heats the air so intensely that it immediately expands and separates. Almost as quickly, the air cools and contracts again. These rapid vibrations of the air come to our ears as a peal of thunder.

The heat caused by lightning is greater than any we can imagine. As the lightning flashes through a tree on its way to the earth, it changes sap to steam with enough power to split the wood. In dried wood, the intense heat rapidly kindles

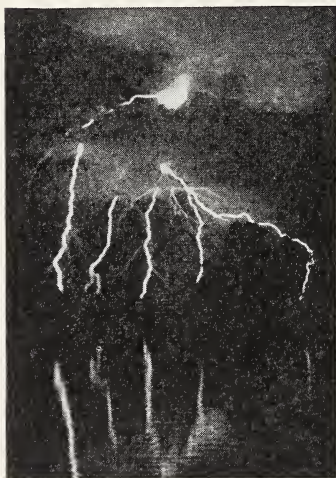


FIG. 19-8. LIGHTNING FLASHES FROM CLOUDS TO LAKE.

a raging fire. Even when there is no direct contact, a shock caused by lightning may bring instant death to man or beast.

Lightning and thunder have always been feared by man. But when we see a flash, we can be sure that the lightning that caused it has already done all the damage it can do. We may hear the crash of thunder some seconds after we see the flash of lightning. Although both the light and the sound were produced at the same time and place, the light of the flash was racing towards us at a speed of 186,000 miles a second while the sound was trailing along at one-fifth of a mile per second. If 5 seconds elapse between the time we see the flash and the time we hear the thunder, we know that the lightning flash was a mile away.

Lightning flashes often strike tall objects and good conductors of electricity. During a thunderstorm we should be careful not to remain beneath isolated or tall trees, or close to steeples, chimneys, stove pipes, fireplaces, plumbing and heating systems, or radios and other instruments connected with electric wires.

Lightning rods prevent buildings from being struck by lightning. The pointed rods above the building allow any electricity in their neighbourhood to go through them to the earth. From the rods, heavy copper wires carry the current safely past the building to plates buried in the damp soil.

A Problem

During a thunderstorm 7 seconds passed between the appearance of the flash of lightning and our hearing of the thunder. A little later the difference in time was 3 seconds. Was the storm moving towards or away from the observer?

Test Questions

1. What is meant by atmosphere?
2. How does the temperature of the air affect the amount of water vapour that may be present in it?
3. What conditions cause water vapour to condense?
4. What instrument is used to measure rainfall? Air pressure? Wind velocity? Wind direction? Temperature?

5. What becomes of a fog?
6. Why is frost more likely to appear on a clear night than on a cloudy night?
7. What conditions tend to prevent dew from forming?
8. Why does one's breath become visible on a cold day?
9. What changes in weather may we expect when the wind shifts from south to west and the barometer is rising? When the wind shifts to the east and the barometer is falling?

Your Word List

Water vapour, evaporation, vapourization, condensed, condensation, humid, saturated, cumulus clouds, cirrus clouds, stratus clouds, nimbus clouds, fog, water cycle, barometer, humidity.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "The Weather Prophet and His Wisdom", Vol. WXYZ, pp. 77-82.

16 mm. Sound Films

Ontario Visual Education Branch

The Clouds Above (SG-48)

What Makes Rain? (SG-20)

Thunder and Lightning (SG-47)

The Water Cycle (SG-27)

Film Strips

National Film Board of Canada

How Weather Maps Are Made

Ryerson Film Service, Toronto

Why Does the Wind Blow?

20

WEATHER IN DAILY LIVING

WEATHER HAS ALWAYS moulded man's way of living. Rain has nourished his crops. Wind has helped to sail his boats, pump his water, and grind his grain. Hurricanes and tornadoes still bring death and devastation, and clouds and fogs make travel by air more hazardous. To avoid the heat of summer and the cold of winter, some of us move to summer cottages and southern winter resorts. Weather gives employment to house builders and coal miners, to manufacturers of clothing and dealers in refrigerators, and, of course, to meteorologists. Indeed, weather helps to determine our food and shelter, our labour and leisure, and our health and happiness.

Think of These

1. How does our clothing differ from season to season? Why?
2. In what ways are our activities changed by weather conditions from day to day and from season to season?
3. How are our eating habits modified by weather?
4. What foods are likely to be damaged during transportation if the weather is too hot? If it is too cold? If it is too wet?

Weather, Animals, and Plants

Weather Determines How Animals Live. Animals adapt themselves in different ways to changing temperatures, to storms, and to the seasonal variations in foods available to them.

PUPIL INVESTIGATIONS. *How does weather affect animal life?*

Make a list of (1) animals that avoid winter hardships by migrating, by hibernating, or by building homes in or beside water; (2) animals that seek shelter from rain; (3) insects that spend the winter in the shelter of buildings, in the egg state, in cocoons, or as chrysalids in the ground.

To avoid the winter's cold, warm-blooded animals may migrate, hibernate, or remain active where they are. Migrating animals find warmer regions in which to live. Hibernating animals are kept warm both by their shelters and by the burning of body fuel which they stored as fat in autumn. Animals that do



FIG. 20-1. ANIMALS AND PLANTS ARE AFFECTED BY WEATHER.

NOTE: In this drawing the white part of the scene represents snow; the light grey part at the base is frozen soil; and the dark grey strip at the left is soil that has melted and not frozen again.

In the scene, find the following examples of animals being influenced by weather: birds migrating (top); the sparrow (on the stump) fluffing out its feathers; the bird (centre) finding little food above the deep snow, while the other two, where there is little or no snow, find more weed seeds; the groundhog hibernating in its den deep in the frozen soil; the rabbit obtaining temporary protection in a deserted burrow (right).

The plants in the centre are protected by a blanket of snow while those at the left, where the snow is melted, are at the mercy of alternate thawing and freezing of the soil. At the left, find the breaks in the roots of the plants that have their deepest roots anchored in the lower layer of frozen soil while their upper roots have been lifted (heaved) by the re-freezing and expansion of the top soil.

not migrate or hibernate keep warm by living in winter homes, by eating fats or other heat-producing foods, by exercising, and by developing a thicker and warmer covering of fur, hair, or wool. Grouse, squirrels, and mice often keep warm in snow banks; rabbits frequently inhabit woodchuck holes; and quail cuddle to keep each other warm. As a protection against cold, Arctic explorers feed their dogs fats, and bird lovers feed their bird friends suet and sunflower seeds, which also contain fats. In very cold weather, birds fluff out their feathers to thicken the insulating layer of air about them.

Cold-blooded animals remain at about the same temperature as their surroundings. Earthworms and white grubs stay in the soil below the frost level to withstand winter conditions. Most frogs hibernate in the mud beneath streams, and toads and snakes spend the winter in the ground or under some protecting cover.

All weather conditions influence animal life. Intense heat causes both domestic and wild animals to seek shade and water, and drought drives them to lower pastures. Very high and very low temperatures destroy many kinds of insects. Snow compels birds to look for seeds on tall weeds, and for eggs and dormant forms of insects beneath the bark of trees. At the same time, mice and rabbits are forced by hunger to use bark for food.

Things To Do

1. Leave a goldfish in a basin of water where the water will freeze. When the water has thawed and the fish swims around again, you will conclude that fish can withstand cold temperatures.

2. Make an animal mural entitled, "Mr. Weather, You Can't Harm Me!"

Weather Is Important to Plants and Agriculture. Weather affects plants in various ways. Some hardy garden plants grow early in spring from seeds scattered in autumn, but delicate plants are transplanted out of doors only after all danger of frost is past. Garden peas may be grown safely in early spring, but corn, potatoes, and tomatoes, if planted early, may be killed by even the lightest of late spring frosts.

Autumn weather is largely responsible for the brilliant array of autumn colours. When the nights are cold and the days sunny, leaves change from the greens of spring and summer to the bright yellows, oranges, and reds of autumn.

Rainfall may be the friend or the enemy of plants and farmers. With too little rain, plants grow poorly and crops may fail. With too much rain, plant diseases are more likely to destroy crops. The tiny spores that spread wheat rust, mildew, and potato scab from plant to plant can start to grow only when moist.

Because snow contains so much air, it forms an insulating cover that protects garden perennials, clover, and winter wheat during both winter and early spring. At freeze-up time, a layer of snow protects plants by making the change of temperature of the soil around them more gradual. In spring, when alternate thawing and freezing of the ground often kills plants, a thick blanket of snow protects them by keeping the soil around their roots frozen until danger of the soil refreezing and injuring the roots is past. An illustration of this value of snow is often seen in late spring in fields of clover or of winter wheat. Where snowbanks were deep and the snow remained latest in spring, crops grow sturdily; where there was no snow covering the soil, plants may be dead or the crop poor.

The early or rapid melting of snow causes loss to the farmer in two other ways. The water from the melted snow runs off from frozen ground instead of soaking into it and later providing nourishment for plants. As the water runs off, it frequently carries away fertile topsoil and, at the same time, forms inconvenient ditches.

Weather and People

Weather Determines Our Clothing and Our Homes. Our choice of clothes for each season, and often for each day, is determined by weather. In winter, we prefer dark clothes because dark-coloured materials absorb more of the sun's heat than light-coloured materials. In summer, we are more likely to wear white or light-coloured clothes because they are cooler.

Winter clothes should be efficient in keeping the body's heat from escaping: they should be good insulators. Thick, loosely woven garments are warmest because they imprison a great deal of air between their fibres, thus insulating our bodies.

In rainy weather we wear raincoats or other garments made of waterproof plastic or of fabrics treated with rubber or oil to make them water-resistant.

An Exercise in English

Pretend that you are the advertising manager for a clothing store. Write advertisements that you would keep in readiness to publish as soon as the weather forecasts indicated (1) a cold wave, (2) April showers, (3) a heat wave in July.

Weather decides the type of home we live in. Caves protected early man from storms and severe cold or heat. Since then, all kinds of homes—the Eskimo's igloo, the Indian's wigwam, the Arab's and the Laplander's tent, the pioneer's log cabin, and the modern house—have been built to protect people more efficiently from heat, cold, and storm.



FIG. 20-2. ESKIMOS BUILDING THEIR IGLOO.

Wherever hunting and fishing are good, Eskimos build a one-roomed, dome-shaped igloo by arranging blocks of snow in a circle, then laying other blocks spirally above these until the last block covers the centre.

In planning houses, architects take into consideration the weather conditions of the locality. In our latitude, where snow is common, we usually construct sloping roofs. In warmer latitudes, where there is little or no snow, flat roofs are common.

Having built his house to protect his family from cold and storm, man makes the indoor weather to his liking by air conditioning.

We insulate houses and other buildings to keep in heat in winter and to keep out heat in summer.

Weather Affects Travel and Communication. The main weather hazards of travel, whether by air, land, or water, are winds, storms, and fogs.

For safe flying, good visibility is essential. The pilot must have advance warning of fogs and low clouds that would prevent him from seeing mountains, other obstructions, and landing fields. Because rising and falling air currents, common among cumulus clouds, cause what the airman calls "bumps", pilots frequently prefer to fly above the clouds (fig. 19-6). Sleet storms and high, dense clouds limit the height of safe flying. Thunderstorms are particularly hazardous to air travel. Fortunately, the towering cumulonimbus clouds that cause the storms warn pilots in time for them to change their courses.

Travel on land may be hindered by wind, floods, and snowstorms. Winds may block highways by uprooting trees. Swollen streams may undermine or flood highways and railways and wash out bridges. Snow becomes a costly nuisance when it accumulates on city streets or when it drifts across railways and highways.



FIG. 20-3. SNOW BLOCKS HIGHWAYS.
A caterpillar tractor ploughing out the roadway past a school.

Transportation on water is hindered by ice and fog. Solid ice sheets or floating icebergs limit the courses of ships in cold latitudes. In London, England, the occasional "pea soup" fog costs millions of dollars in shipping losses.

Communication by wire is frequently interrupted by sleet and ice storms that weigh down the wires and snap the poles.



FIG. 20-4. ICE STORMS INTERRUPT COMMUNICATIONS AND CAUSE DANGER. Find all the evidences you can that the ice storm damaged communication wires and trees.

Weather Influences Our Comfort and Our Health. We learned in chapter 10 that air, to be healthful, should be at the correct temperature, sufficiently humid, as free as possible from impurities, and in constant motion. This is as true outdoors as indoors.

Fogs and clouds make the atmosphere unhealthy. When the air is very moist, infected droplets from a cough or sneeze float around for a longer period of time than when the air is dry. As a result, epidemics of influenza, measles, and scarlet fever usually come in rainy or damp seasons. Circulation of the air, however, tends to carry bacteria to higher levels where sunlight may destroy them. Stormy weather is known to cause increased pain to people suffering from arthritis and rheumatism. Clouds and fogs screen from us the sun's ultra-violet rays which are so necessary for good health.

A dry atmosphere out of doors adds to our comfort. It makes cold winter days feel less cold, and hot summer days feel less hot.

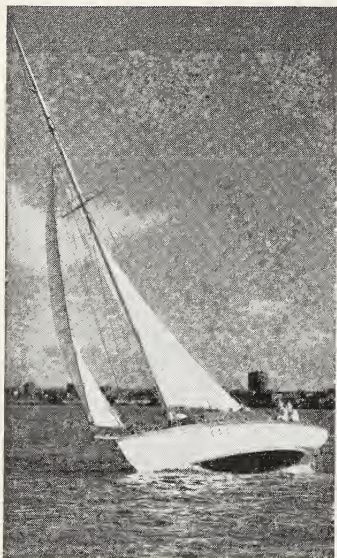


FIG. 20-5. ENJOYING A COOL SUMMER BREEZE WHILE YACHTING IN VANCOUVER HARBOUR.

A summer breeze refreshes us by cooling. As the air moves along, it carries away the warm, moist air next to the skin and brings drier air in its place. The fresh, dry air evaporates more moisture from the skin than the moist air could evaporate. As the dry air evaporates moisture from the skin, it uses heat from the body, making us feel cooler. For the same reason, in winter, when the air indoors is dry, we feel cooler than when the air is moist. (See page 187.)

Weather Forecasts Enable Us To Prepare for Coming Weather. Long ago, man watched the skies for signs of future weather. Doubtless, he planned his activities ac-

cordingly. Modern weather forecasts, based on a better understanding of what makes the weather, enable us to plan much more wisely.

Weather forecasts are extremely important to farmers. When rain is predicted, a farmer postpones the cutting of hay or grain and the spraying of crops for the control of insects. However, he may hasten to pick strawberries or other perishable fruits, or to haul grain to the barn. Forecasts of frost in late spring warn market gardeners not to transplant their tomatoes. Similar forecasts of frosts cause fruit growers of California and, to a limited extent, of the Okanagan Valley in British Columbia to protect their fruit blossoms by using oil stoves to heat their

orchards. Forecasts of early autumn frosts caution farmers not to delay cutting tobacco or corn crops.

The safe transportation of perishable goods is assisted by weather forecasts. When shippers of perishable fruits and vegetables know that a cold spell is approaching, they adopt safeguards to protect their products from frost during transit.

Travel by air is made safer by weather information supplied by the Meteorological Service. Advice to airlines enables them to postpone or, if necessary, cancel flights when weather conditions are not favourable for flying. This protects passengers and property.

Ships at sea and on the Great Lakes can take the necessary steps to save life and property when warned of approaching storms by radio, signal flags, or warning lights.

Motorists plan their journeys, especially in winter, in keeping with forecasts of sleet, snow, or extreme cold.

Weather forecasts influence our plans in many other ways. They warn Highway Departments to prepare their snow-ploughs for action. Telephone companies are warned when to have their crews of men ready to repair wires. Knowledge of dry conditions in forests help forest fire authorities to be on the alert to detect and put out forest fires. Most of us listen to the weather forecasts to help us plan our clothing, our travel, and our recreation.

Test Questions

1. In what ways is health influenced by weather conditions?
2. What farm activities are usually connected with dry weather? With wet weather?
3. What kinds of information from weather forecasts are valuable to a farmer? To a commercial traveller? To a fisherman? To an aviator? To a fruit grower? To a fruit importer?
4. What kinds of weather conditions are most hazardous to airliners? Why?
5. How does snow protect plants in early spring?
6. How are wild animals affected by weather conditions?

Film Strip

National Film Board of Canada

All Kinds of Houses



UNIT NINE

Conservation of Wildlife

21. *HOW WILDLIFE HELPS US*

Early man and the pioneers depended upon wildlife to some extent for food and clothing. Even today, wildlife supplies many useful products, including food and fur. Fish, deer, and other forms of wildlife provide healthful recreation and are a strong attraction to tourists. Is there any one of us who does not enjoy the chattering of squirrels, the sweet songs of birds, and the shimmering colours of brook trout as they dart for flies?

22. *WE MUST CONSERVE WILDLIFE*

When man cut the forests, ploughed the prairies, and drained swamps, he changed the fate of many kinds of wildlife. Some migrated; some became fewer and fewer in number; and some vanished, never to return. We can protect and conserve the remaining wildlife—our song birds, our game animals and fish, our wild flowers—by practising the Golden Rule, by respecting game laws and regulations, and by maintaining game preserves and national and provincial parks. We can improve the environment for wildlife permanently by planting trees and shrubs for shelter and food, and by conserving water, soil, and forests. Let each of us determine to do something to conserve wildlife for future generations to use and enjoy.

21

HOW WILDLIFE HELPS US

WILDLIFE CONSISTS OF ALL PLANTS and animals that live in their natural environments without the care and protection given by man to domestic animals. The term includes all wild plants of field, forest, and roadside, and all mammals, birds, reptiles, amphibians, fish, insects, earthworms, and smaller animals of field and forest, lake and stream.

Canada's early forests contained a wealth of wildlife. Some of the more important kinds are classified as follows: *big game* — deer, moose, elk, caribou, buffalo, mountain sheep, mountain goat; *game birds and upland game* — bobwhite quail, pheasant, grouse, squirrels, jack rabbit, cottontail rabbit; *water fowl*—Canada goose, ducks, swans; *fur-bearing animals* —raccoon, mink, muskrat, skunk, woodchuck or groundhog, fox, weasel, wolf, fisher, marten, wolverine, lynx, otter, and bear.

Early Man and the Pioneers Depended upon Wildlife

Wildlife has always been important to man. Before he domesticated animals, man used the flesh of the larger wild animals for food, and their hides for shelter and clothing. Wild animals provided the early Indians with many of life's necessities. After the white man came, the furs of wild animals became



WILDLIFE IN CANADA

NATIONAL PARK SITE



FIG. 21-1.

barter for new luxuries. Wildlife was the first product of the soil used by pioneer settlers in Canada before they had sufficient livestock and field crops to supply all their food. From deer, rabbits, pheasants, and ducks they obtained food; from the hides of fur-bearing animals, they made coats and rugs. Hunting and fishing were not merely recreation and sport: they were a necessity.



FIG. 21-2. CANADA'S FIRST POSTAGE STAMP.

The beaver deserved the early recognition it received when it was pictured on Canada's first postage stamp, a small, red three-pence stamp (fig. 21-2). As a symbol of intelligence and industry, it became Canada's emblem. The

beaver has always been our most important natural conservationist. Beaver dams help to prevent floods in spring. Their ponds provide homes for fish and other wildlife, and feed out enough water to keep creeks flowing throughout the summer.

Values of Wildlife Today

Wildlife is still important to all of us. We enjoy the songs and flashing colours of songbirds, the graceful forms and movements of deer, and the beauty and fragrance of wild flowers.

Some of us take pleasure in hunting, perhaps with a camera instead of a gun. Many enjoy a tasty dinner of fish or game birds, taken in legal season. In winter, we appreciate the warm furs provided for us by Canadian fur-bearing animals.

Wildlife Supplies Useful Products. Fish, game, and other wildlife have made even wild and rough parts of Canada valuable. Wildlife is an important crop of about two-thirds of the area of Canada. Two of Canada's oldest industries, trapping and fishing, depend upon wildlife. These industries, and the furs and food they produce, are still important in Canada.

Furs from Wildlife. The lure of furs enticed explorers far into the wilds of the Canadian North-west and attracted European traders to Canada. Thus fur-trading became Canada's first industry, and beaver pelts became Canada's first currency.

The fur industry gives employment to trappers, manufacturers, and retailers. Because wild animals do not have to be fed or cared for, the income from furs sold by trappers is largely profit. In some parts of Canada farm boys have made money easily by trapping muskrats, foxes, skunks, and minks. In Ontario the most important of the fur-bearing animals, based upon the value of the furs taken, are muskrats, beavers, weasels, and minks.

One has only to consider the large number of people wearing garments made of fur to realize the enormous value of furs manufactured and sold in Canada (fig. 21-3). To meet this demand, more than seven thousand fur farms have been established in Canada. Canada has now become second only to the United States in the production of furs.

The value of muskrat pelts exceeds that of all other pelts taken in Canada. These are made into coats and other garments

and sold under such names as plucked beaver, Hudson seal, and electric seal, as well as muskrat. Muskrats live in marshes where they build their homes of grasses, cattails, and rushes, matted and woven together (fig. 21-4). Unlike beavers, they do not build dams. In addition to grasses and cattail roots, muskrats eat clams, dead fish, and other animal matter. To improve



FIG. 21-3. FURS CONTRIBUTE TO CANADA'S WEALTH.

the environment for muskrats, large areas of marshes have been re-established in Canada, particularly in Manitoba.

Food from Wildlife. Fish, game birds, and game animals all provide food for man. In fact, they provide most of the food available to residents of the far north whether they be Indians, Eskimos, or white men. Wildlife in Canada supplies several thousand tons of nourishing meat to Canadians annually.

Fishing is one of Canada's important industries. From the oceans are taken such salt-water fish as salmon, halibut, and cod; from rivers and lakes, such



FIG. 21-5. FISHING IS GOOD RECREATION AND SPORT.

This fisherman seems well satisfied with his catch.



FIG. 21-4. MUSKRAT HOMES IN A MARSH.

Find: the large muskrat home in the foreground, the smaller home in the right-hand background, and the cattails and other marsh plants.

fresh-water fish as whitefish, pickerel, pike, bass, and lake trout; and from small streams, the much-prized speckled trout. The fish of Canada's inland waters provide both food and sport to an extent not equalled by any other country in the world. In most places the waters are sufficiently cool and shaded to make acceptable homes for fish. Unfortunately, pollution of water by erosion, by wastes from industries, and by sewage from settlements have made many streams uninhabitable by fish.

Such big game as moose and deer, game birds such as grouse and wild ducks, and small animals such as rabbits and raccoons provide meat for many Canadians, especially in the sparsely settled areas.

Wildlife Provides Enjoyment and Healthful Recreation.

Labour and recreation—work and play—fill most of our waking hours. Some favourite forms of recreation are: observing, studying, and enjoying the interesting habits of wild plants and animals; drawing, painting, or photographing those phases of nature that appeal to us most; and fishing or, perhaps, hunting game birds and big game. Because wildlife makes possible all these kinds of recreation, it adds to our enjoyment of life, contributes to better health, and teaches us many things that are both interesting and worth knowing.

Nature lovers find all sorts of interesting things to enjoy as their eyes observe and their ears listen to wildlife. We enjoy seeing the flashing colour of a red-winged blackbird, the silver glint of a trout jumping for a fly, the graceful flight of a swan, the industrious labour of a beaver, a goldfinch picking seeds from a thistle head, a hawk soaring high, or a rabbit scurrying across the highway to safe cover. We thrill to the song of a robin in the garden or of a song sparrow in dense shrubbery by a stream. We listen with pleasure to the chattering of a squirrel, the call of a crow, the drumming of a grouse, the whistling of a groundhog, the chirp of a cricket, or the hoot of an owl. We appreciate the sweet perfumes, the graceful forms, and the delicate colours of wild flowers, and the activities of snakes and salamanders.

Some forms of wildlife appeal to us so much that we want to paint, draw, or photograph them. Close your eyes for a minute and imagine you see some of these: colourful autumn trees and shrubs with an undergrowth of goldenrods and purple asters; a powerful moose standing in a cool stream, eating the foliage of a tree that shades him from the summer heat; the web of a garden spider laden with dew drops glistening in the morning sun; a raccoon looking out from its hollow-log home

(fig. 22-9); or the gaping mouths of hungry baby robins begging insects from their mother (fig. 6-2,B). Who would not try to paint such interesting bits of nature, or wish he could picture them with a camera?

While we observe and associate with wild plants and animals for our enjoyment, we learn about many of their marvellous ways of living.

Knowledge never learned of schools,
Of the wild bee's morning chase,
Of the wild flower's time and place,
Flight of fowl and habitude
Of the tenants of the wood,
How the tortoise bears his shell,
How the woodchuck digs his cell,
And the ground-mole sinks his well.

John Greenleaf Whittier

The more we learn about the habits and adaptations of any wild plant or animal, and about the ways in which it helps or hinders other living things, including ourselves, the more wisely we can decide whether we should give it our protection.

Many good sportsmen enjoy the rest from business responsibilities, the carefree relaxation, and the helpful exercise obtained through fishing and hunting. To the pioneers, these activities were essential to obtain food and clothing. In the forest they hunted grouse, deer, elk, bear, and moose; around water they found ducks and geese. With more open country today, we may hunt quail and pheasants, but elk and moose have become scarce even in the forests still standing.

True sportsmen obtain their greatest recreational satisfaction when they have matched their skill fairly against the cunning and fight of a sporting type of fish—and won, or when they have had to use the most skilful shot to take a deer or grouse.

A sportsmanlike fisherman or hunter always refrains from fishing and hunting out of season, limits his prey to the legal size and number, and cheerfully obeys all laws and regulations made to protect wildlife. The highest law of good sportsmanship

is the *Golden Rule*—towards wildlife and future sportsmen.

Canada still possesses vast areas of wild territory well stocked with such game birds as ducks, geese, and grouse, and such big game as deer and bears. Much of northern Ontario, covered by virgin forests, is a wildlife paradise. Waterways and railways, highways and skyways furnish means of travelling to these wildernesses to enjoy the recreational opportunities they provide. Deer, bear, and other big game are more abundant in northern wilds, and such upland game as pheasants and quail are more commonly found close to settled areas in southern Ontario.

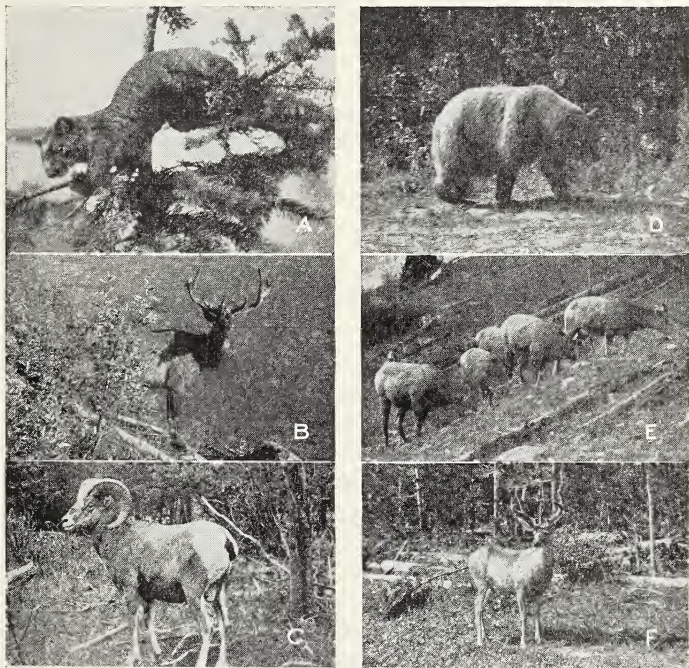


FIG. 21-6. SOME OF CANADA'S WILD ANIMALS.

A, marten; B, elk; C, big-horned ram; D, black bear; E, Rocky Mountain sheep; F, deer.

Some Important Kinds of Wildlife

Types and Names	Habitats and Characteristics	Importance
<i>Big Game</i>		
White-tailed Deer	In forested and brushy areas; alert and graceful	Hunted in open season
Barren Ground Caribou	In groups or herds in northern barren grounds; resemble reindeer	Fresh meat for residents; hides for clothing
Woodland Caribou	In wooded areas; not in large herds	Now scarce; formerly a source of meat and hides
Buffaloes	Originally plentiful on western plains, then nearly exterminated; found in national parks	Historical interest; food when slaughter permitted
Moose	Largest member of the deer family; live near water in dense forests; feed on aquatic plants and tender twigs	Now scarce; heads formerly much-prized as trophies
Mountain Sheep	Live on high mountain peaks	Wool formerly woven into blankets by the Indians
Rocky Mountain Goats	Pasture on mountain peaks above the timber line in summer	Excellent meat; massive horns prized as trophies
<i>Fur-bearers</i>		
Black Bears	In forests and in unsettled regions; feed on fruit, other vegetation, and many animals; hibernate	Taken for their pelts
Beavers	In forested regions along streams; intelligent and industrious	Their dams make ponds and conserve water; one of Canada's most important fur-bearers
Red Foxes	A symbol of cunning and grace; found all across Canada where there are trees	Popular for fur; fox farming an important industry
Minks	Prefer a habitat near water; enemies of muskrats; eat other water animals	Produce very valuable fur; raised on fur farms

Types and Names	Habitats and Characteristics	Importance
Weasels	Become white in winter; ferocious flesh eaters; little preference with respect to habitat	Winter pelts sold as ermine; eat many mice
Muskrats	Small rodents; build lodges in marshes; very plentiful in parts of Canada	Soft, thick underfur and long outer hair make their fur popular for coats; fur sometimes called Hudson seal
Wolves	Belong to the dog family; do not attack people; one variety named coyote	Injurious to sheep and deer
Martens	Almost extinct because of over-trapping; beautiful and graceful; live in remote forests	Fur attractive and valuable
Raccoons	Found in woods near streams and lakes; live in hollow trees; eat both animal and vegetable food	Caught for their flesh and fur
<i>Game Birds and Waterfowl</i>	See chapter 6	

How Wildlife Helps Agriculture. Many kinds of wildlife are useful to farmers. Among them are birds, skunks, foxes, weasels, beavers, snakes, frogs, toads, and earthworms.

The lives of many kinds of birds depend upon their finding insects for food. Birds such as woodpeckers, nuthatches, brown creepers, and chickadees live entirely on the insects and their eggs that are usually found on trees. Thus they protect orchard trees and shade trees as well as forest trees from leaf-eating and wood-boring insects. Meadowlarks, bluebirds, and robins devour ground insects, many of which are injurious to farmers' crops. Hawks and owls reduce the number of mice, rabbits, and woodchucks that feed upon crops. Birds that feed chiefly on seeds help farmers by devouring large quantities of weed seeds. The stout, cone-shaped bills of sparrows, quail, pheasants, juncos, snow buntings, and horned larks enable these birds

to eat hard seeds, some above the snow in winter. Thus, they protect farmers' crops by reducing the competition they have from weeds. Several of these seed-eating birds feed their nestlings with insects, many of which are injurious to crops.

Many other kinds of wildlife make a contribution to agriculture. Skunks eat grasshoppers, white grubs, and cutworms. Although weasels and foxes occasionally take poultry, we may well consider this a payment for their services to farmers by eating such destructive rodents as mice. Frogs, toads, and snakes all devour large numbers of injurious insects. The dams of beavers often prevent spring floods and conserve water which is fed out to streams gradually throughout the summer, helping farmers' crops by keeping the water table higher in the soil, and helping fish by keeping streams flowing all summer. As we learned in chapter 3, the lowly earthworms improve the soil as they dig their burrows.

Wildlife Supports Business. Wildlife is valuable to business in several ways. Fish and game animals attract tourists to fish and hunt. The tourists contribute to the income of railways, service stations, the owners of tourist resorts, and of those who sell guns, ammunition, fishing tackle, camping equipment, food, and clothing. It is estimated that tourists from the United States alone spent nearly \$300,000,000 in Canada in 1953. As we have mentioned earlier in this chapter, fur-bearing animals and fish provide raw materials for some industries, make possible many useful products, and give employment to those engaged in the industries and in marketing the products.

Some Wildlife Is Harmful

Although every kind of plant and animal has its place in nature's pattern and has some value to other living things, some plants and animals are harmful to man or to those living things that serve man. In previous chapters we have learned of the harm done by many injurious insects, by mice, and by some injurious birds. Woodchucks (groundhogs) feed on farmers'

grain, grass, and clover. The soil removed when they dig their burrows covers and destroys useful farm plants. Frequently, the partly hidden burrows cause horses to stumble and, perhaps, become injured. Gophers, sometimes called ground squirrels, are common on the western prairies. They resemble groundhogs in form and habits, but are smaller. The damage they do is somewhat similar to that caused by groundhogs. See fig. 21-7, A and B. The coyotes of western North America, often called prairie wolves, resemble small collie dogs. Their feeding habits make them partly helpful and partly harmful. They eat insects, rodents, and the remains of dead animals, but they sometimes kill lambs.



FIG. 21-7. TWO HARMFUL ANIMALS THAT LIVE IN THE GROUND.
A, groundhog; B, gopher.

Things To Do

1. (a) Make a survey of wildlife found in your community. You may obtain help from nature lovers, game wardens, trappers, hunters, and farmers.
- (b) Classify the animals in your list as helpful or harmful.
- (c) Investigate the feeding habits of each animal mentioned, then consider whether you have classified it correctly.
2. Collect samples of fur. Name the sources and uses of each. A furrier could assist you.
3. For each of several fur-bearing animals, find out at what season the animal should be trapped or hunted if (a) its production of young is to be interfered with as little as possible and (b) the fur is to be obtained in the best condition.
4. Try to identify some wild animals by their tracks.

5. Investigate and discuss the main methods of trapping and hunting.
6. Make a list of common fish caught in local streams and lakes.
7. Make pencil drawings to show the shape and markings of several kinds of fish.
8. Collect and mount labels from packages and cans of preserved fish sold in stores.

Read

Compton's Pictured Encyclopedia, 1953: "Deer", Vol. DE, pp. 43-45; "Principal Food Fishes of the World", Vol. F, pp. 108-109; "Workers with Trawl, Net, and Line", Vol. F, pp. 112-118; "The Fur Trade—A History of Heroes and Rogues", Vol. F, pp. 321-326; "Plant and Animal Life of North America", Vol. NO, pp. 258-263.

16 mm. Sound Films

Ontario Visual Education Branch

Fur Seal (SN-103)

Algonquin Waters (SS-6)

Fur Country (James Bay area) (SS-61)

Common Animals of the Woods (SN-106)

National Film Board of Canada

Jasper (colour)

Fur Trade

Gaspé Bay Cod Fishermen (colour)

Indian Hunters

Canadian Smallmouths (colour)

Speckled Trout across Canada (colour)

Age of the Beaver (history of fur trade in Canada)

Film Strips

National Film Board of Canada

Larger Land Mammals of Canada (colour)

The North American Moose

The Barren Ground Caribou

WE MUST CONSERVE WILDLIFE

WE CONSERVE WILDLIFE when we use it wisely and leave enough of it in such favourable natural surroundings that it can thrive and multiply and meet the needs of people who follow us as well as it meets our needs today.

The reports of early explorers and settlers in Canada tell of unlimited numbers of big game and fishes, a wealth of fur-bearing animals, and hordes of wild fowl. The Indians had taken only such wildlife as they needed for food, clothing, and shelter. Moose, deer, elk, bears, and beavers, as well as grouse, wild turkeys, and passenger pigeons were plentiful in the eastern



FIG. 22-1. A HERD OF BUFFALOES ON THE CANADIAN PRAIRIE.

forests. Wolves, lynxes, bobcats, martens, beavers, and fishers lived in large numbers in the northern forests. Numerous mountain goats, big-horned sheep, and grizzly bears inhabited the mountains of the far west. On the western prairies lived countless numbers of buffaloes and antelopes, coyotes and badgers; and early hunters found a wealth of beavers, minks, otters, and raccoons along streams everywhere.

Wildlife Is Being Depleted

The passenger pigeon is gone forever. Buffaloes exist only in protected parklands. Streams that once teemed with speckled trout or bass are now dry or unfit for fish. The supply of big game and of game birds has diminished steadily in spite of efforts to conserve them. Our fur-bearers have been gradually reduced in numbers by the fur trade.



FIG. 22-2. THESE WERE A PART OF CANADA'S WILDLIFE.

Try to identify the heads of big game. Find also the owl, game birds, and fish.

Man Has Destroyed the Habitats of Wildlife. Wild creatures, like people, must have a place to live, a place for a home, for protection, and in which to obtain food. Moose, grouse,

and many other wild animals prefer to live in forests; buffaloes and gophers, on the grassy prairie; pheasants and bobwhite quail, in open fields; otters and beavers, beside streams; red-winged blackbirds and muskrats, in marshes; and fish and clams, in water. The special sort of place in which any plant or animal chooses to live is called its *habitat*. When the natural habitat of any wild animal is destroyed or in any manner made unsuitable, the animal must either migrate, adapt itself to the new conditions, or perish.

When the pioneers settled in Canada, they destroyed or changed the habitats of many wild animals. The first problem of the settlers was to build homes and clear land on which to make a living. As we read further, we must remember that they had no way of knowing that they would change the wildlife population so greatly as they cut the forests, ploughed the prairies, and drained the swamps.

When settlers cut the forests, they destroyed the protective cover, the home sites, and the natural foods of deer, foxes, beavers, martens, raccoons, minks, rabbits, wild pigeons, and many songbirds. Many of these animals escaped farther north. Bears and wolves that remained and attacked calves and lambs were tracked down and killed. Raccoons cultivated a liking for corn, and skunks learned to search for insects among the crops. Some songbirds remained and served the pioneers by eating insects and weed seeds.

While a forest stands, the soil in the forest floor, like a huge sponge, absorbs and stores the water of melting snow and spring rains. In the months that follow, the water gradually drains away, filling creeks and rivers and making them good homes for fish throughout the summer. Where man has cut the forests, the waters rush away as destructive floods in spring, and the streams may dry up in summer, leaving the fish to perish. As the water flows over the land, it wears away fertile topsoil and carries it into streams. Such streams, once crystal clear and excellent homes for fish, become so muddy that neither the fish nor the water plants on which they feed can exist.

By ploughing the prairies, man drove away the buffaloes and antelopes, causing many of them to perish from starvation. At the same time, he destroyed the nesting places of prairie birds and killed off the colourful prairie flowers.

Man continues to destroy the habitats of wildlife. When farmers drain marshlands and shallow lakes to produce more farm land, they destroy the breeding grounds of ducks and other useful water birds, and the home sites of such valuable furbearers as minks and muskrats. When men clear the banks of lakes and streams by removing the trees and shrubs, they expose the water to sunshine, making it too warm for most fish.

Many bodies of water have been made unfit for fish and wildlife by other changes brought about by man. Streams near cities and towns have become polluted by sewage; and those near industries and factories have been contaminated by wastes from them. Not only is the fouled water shunned by fish and water birds; it may be actually poisonous to them. Oil on water so clogs the feathers of ducks and other water fowl that they perish.

Too Many Game Animals and Fish Are Being Killed. Indians seldom killed wildlife for sport. They took only enough game and fish to satisfy their immediate needs. When wildlife became scarce in one locality, they hunted elsewhere until the game had an opportunity to increase again. Most of the first white settlers also took only as much wildlife as they needed. When railways made it possible to ship game to distant markets, hunters took buffaloes, wild turkeys, wild geese, and other game in increasing quantities for profit.

Not many years ago most of our streams provided good fishing throughout the summer for all who wished to enjoy the sport. Now fish are scarce in most large lakes within driving distance of cities. Even distant lakes that cannot be reached by railway or highway are being fished out by fishermen who travel by air from far and near. When we realize that Ontario

alone issues annually over half a million licences to hunt or fish, we have some idea of the extent to which game and fish are being caught.

The automobile takes an enormous toll of wildlife. Rabbits, pheasants, squirrels, skunks, snakes, frogs, and turtles frequently fall prey to speeding cars. Rabbits spend a lifetime in a small area, often with a highway running through it. In play, or in search of food, they dart back and forth across the path of passing automobiles. Pheasants often search for grain or insects on the roadside, and squirrels frequently cross highways to hunt for food. Little wonder so many animals become victims of highway traffic!

Some Kinds of Wildlife Have Been Exterminated. The last passenger pigeon died in a zoo in 1914. Man's greediness in hunting it, largely for food and sport, had gradually reduced its numbers from millions. Though wild turkeys were once very plentiful in Ontario, only a small protected colony remains. Bobwhite quail in Ontario, and prairie chickens on the western prairies, both abundant at one time, are now very scarce. The beautiful, white trumpeter swan, the largest native water fowl in North America, has been almost exterminated.

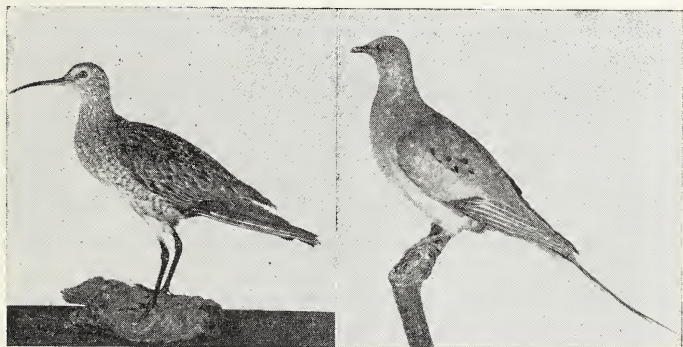


FIG. 22-3. TWO BIRDS THAT ARE NOW EXTINGUISHED.
Left, the Eskimo curlew; right, the passenger pigeon.

Though there were millions of buffaloes and many antelopes roaming the western prairies when the white man came to Canada, they exist today only in protected game reserves. The woodland caribou, once abundant in northern Ontario, is nearly extinct, and moose are scarce in many areas. Martens and fishers, two of our best fur-bearers, are now few in number. The picturesque big-horned sheep of the Rocky Mountains has disappeared from most of the mountain areas it once inhabited.

Some wildlife has disappeared or become scarce because man destroyed its protective cover and food; most wildlife has been the victim of man's greediness. There is still time to save some of those species that have become scarce, but this can be accomplished only with the co-operation of all of us, especially of hunters.

We Can Protect the Remaining Wildlife

When we speak of protecting muskrats (or any other wild animal), we are not thinking of keeping them safe from minks and hawks; we mean that we want to help them maintain a population sufficiently small that all will have enough to eat, yet large enough to meet the demands of animals that feed upon them and of people who trap them. In this sense, protection means trying to establish a proper balance in nature with respect to muskrats. To protect muskrats, therefore, we may have to provide them with better living conditions, kill some of their enemies, or limit the number men may trap.

The two most common methods of protecting wildlife are (1) making and enforcing laws and regulations that protect the animals from excessive hunting, trapping, and fishing, especially in the breeding season, and (2) establishing wildlife sanctuaries or places of refuge in which wild plants and animals may live and multiply with greater safety.

Protecting Wildlife by Laws and Regulations. When our forefathers realized that certain species of fish and wildlife were being destroyed too rapidly and becoming scarce, they passed laws to protect them. The Fish and Game Division of

the Ontario Department of Lands and Forests is responsible for the protection of fish and wildlife throughout Ontario. Each province passes its own laws to protect fish and game animals. Game laws and regulations are changed from year to year according to the needs of wildlife.

PUPIL INVESTIGATIONS. *How do laws and regulations in your province protect wildlife?*

1. Obtain from your Provincial Department of Lands and Forests a copy of the laws and regulations of the present year to protect fish and wildlife, also information concerning provincial fish hatcheries and wildlife preserves.

2. Find out what purposes are served by: (a) preventing fishing during spawning seasons; (b) setting apart certain days or periods of time during which it is illegal to hunt game and catch certain kinds of fish; (c) making it illegal to retain fish smaller than a certain size.

Laws to protect our fish tell us when we may catch certain kinds of fish, by what methods we may catch them, how many of them we may catch per day, and how large each fish caught must be if we are to retain it. Laws also forbid the sale of certain fish. The purpose of these laws is to permit fish to mature and lay eggs before they may be caught, to make certain that they will not be caught at all in spawning season, and to prevent wholesale slaughter.

Ontario has similar laws and regulations to protect game birds and big game. Caribou and moose may not be shot at all. Deer are protected by regulating the open season in which they may be shot, the number any person may shoot in one open season, and the methods by which they may be hunted. Pheasants, grouse, and such migratory birds as wild geese and wild ducks are protected by limiting the season in which they may be shot, the number that may be taken, and the methods of hunting. In Ontario a licence must be obtained by both residents and non-residents to hunt big game or game animals.

Inspectors and game wardens render a service to all of us when they enforce laws and regulations to protect our fish and wild game. All loyal citizens and true sportsmen will co-operate

with these men to help conserve our wildlife for others who come after us to use and enjoy.



FIG. 22-4. A CONSERVATION OFFICER TALKS ABOUT THE BEAVER TO PUPILS IN CHAPLEAU HIGH SCHOOL.

Those who enjoy and appreciate wildlife will respect the laws and regulations made to protect it.

Wildlife Sanctuaries. Areas set apart to provide shelter, safe homes, and protection for wildlife are called wildlife sanctuaries. They may be large areas, such as our national and provincial parks, or they may be small areas known as game preserves or bird sanctuaries.

National and provincial parks are areas set apart by the federal and provincial governments respectively to be preserved in their natural state as outdoor museums of living things. They serve two important purposes: they protect such wild animals as buffaloes, elk, Rocky Mountain goats, big-horned sheep, moose, beavers, fishers, and martens by providing them with safe habitats in which they may find food and shelter without fear; they show people how interesting and enjoyable our wildlife can be. Although people may visit and camp in these parks, and may fish in them, they are not permitted to hunt, trap, or molest other wildlife.

PUPIL INVESTIGATIONS. *Find the location of some of the following national and provincial parks in which wildlife is protected.*

1. National parks: *Elk Island National Park*, a fenced preserve near Edmonton, Alberta, containing Canada's national herd of buffalo, also deer, elk, and moose; *Wood Buffalo National Park*, in Alberta and North West Territories, containing a large herd of buffalo and other game; *Riding Mountain National Park*, in Manitoba, and *Prince Albert National Park*, in Saskatchewan, both of which give refuge to deer, elk, buffaloes, moose, and beavers; *Point Pelee National Park*, on the north shore of Lake Erie, a bird sanctuary for Canada geese, wild ducks, and other migrating birds on their way north; *Fundy National Park*, in New Brunswick, a game sanctuary; *Banff National Park*, in Alberta, a game sanctuary—and others.

2. Provincial parks: *Algonquin Park*, in Ontario, containing a wealth of fish and wildlife, and *The Laurentides Park*, in the Province of Quebec, also a sanctuary for fish and wildlife.

Game preserves differ from parks in that they provide protection for game and fur-bearing animals only. They are usually smaller forest areas in which hunting and trapping are forbidden. They may be operated by governments, individuals, or business concerns. To increase the number of furs in the future, fur-trading companies maintain several preserves for fur-bearing animals.

Most animals in wildlife sanctuaries live in such favourable natural conditions that they multiply rapidly. Because the animals are free to leave parks and preserves at will, they gradually increase the population in nearby areas where living conditions are satisfactory. In this manner wildlife sanctuaries make game available in surrounding regions for those who wish to enjoy, hunt, or trap them.

Bird Sanctuaries. Birds that migrate long distances in spring and autumn must be able to find shelter and food wherever they are, and protected nesting places where they can rear their young. Migratory birds are protected in Canada and in the United States through a treaty between the two countries. Each country undertakes to make and enforce regulations to give complete and permanent protection to non-game birds and to protect game birds

by regulating the open seasons in which they may be hunted, the hours and methods of hunting, and the numbers of birds that may be taken.

Because waterfowl are so much in demand for food and sport, they need protection all along the routes of their migration. During a year they need three kinds of protective homes or sanctuaries. In the far north they must have safe places in which to nest and rear their young; along their migration routes they require safe resting and feeding places; in the south they need protected winter homes.

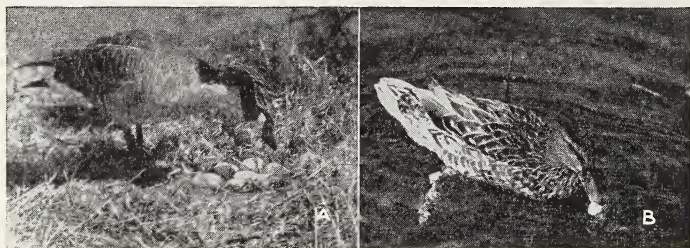


FIG. 22-5. MIGRATORY WATER FOWL.

A, a Canada goose with her eggs; B, a Mallard duck eating on the water.

Canada has established bird sanctuaries in many areas where waterfowl may rest and feed on their way north and south and where they may rear their young. Three migratory bird sanctuaries have been established around James Bay. Point Pelee National Park serves as a temporary resting place for Canada geese, wild ducks, and herons. The Jack Miner Bird Sanctuary, at Kingsville, Ontario, has for many years been a resting and feeding place for thousands of migrating ducks and geese (fig. 22-5). Sanctuaries along the seashore provide many long-distance water migrants with food and safe resting places.

Throughout Canada many sanctuaries have been established for songbirds and game birds. A songbird sanctuary should provide for the birds the following: trees, shrubs, and vines for nesting sites, shelter, and food; fresh water for drinking and bathing; feeding stations and nesting boxes; and protection from

their natural enemies. For game birds such as pheasants and grouse both shelter and food are needed in winter. Evergreen trees, brushy fence rows, and man-made shelters protect them from weather and natural enemies. For food, we may leave patches of grain or shocks of corn in the fields, or we may feed them cracked or whole grain under protecting cover.

See chapter 6 for other methods of protecting birds.

Protecting Wild Flowers. Wild flowers are harbingers of spring. Hepaticas lift their dainty heads above the dead leaves on the forest floor before the first trees and shrubs open their leaves and flowers. We enjoy the delicate colours, the graceful forms, and the sweet perfumes of these and later wild flowers.

Unfortunately, we have fewer opportunities than our parents had to enjoy wild flowers. The sweet-scented trailing arbutus that carpeted the forest floors in many parts of Ontario is now rare indeed. Few native orchids can be found in our swamps. White trilliums and columbines are hard to find in many parts of Ontario.

Wild flowers have become scarce for several reasons. Many people have destroyed plants by careless picking of their flowers. The three green leaves of trillium plants are often picked along with the flowers, making it impossible for the plants to manufacture more food to be stored for the next year. As a result, many trilliums have died. Dog's-tooth violet and yellow adder's tongue plants are seven years old when they produce their first flowers. If we pick their leaves with the flowers, we cause the plants to die after but one year's blossoming. Forest fires, the cutting of forests, and the draining of swamps have destroyed the habitats of many wild flowers. Too often we let the wild flowers we have picked wilt before we reach our homes and put them in water, or we pick more wild flowers than are necessary to make an attractive bouquet.

Unless we conserve the remaining wild flowers, there will be few left for the next generation to enjoy. Where flowers are scarce, we should not pick any of them. In fact, we should refrain from picking any of the following species, especially near

cities or towns: bloodroot, columbine, hepatica, Jack-in-the-pulpit, lady's slipper, marsh marigold, Solomon's seal, and trillium. A safe rule to follow is to leave at least twenty flowers for each one we pick. The flowers we do pick should be taken without injuring the leaves or the roots of the plant.

Let us remember that wild flowers are more attractive where nature grows them than in a vase, and that it is good manners to "let them blossom for the many rather than be picked for the few."

Things To Do

1. Make a chart of wild flowers, entitled "Let Live". On it, mount coloured pictures of several kinds that should not be picked. Name each flower. Make up a motto for each to impress the need for conserving it, or give one good reason why it should not be picked.

2. Make posters to encourage other people not to destroy wild flowers, and attach the posters to trees in wooded areas where wild flowers grow.

We Can Improve the Environment for Wildlife

Many kinds of wildlife would be more plentiful if more favourable habitats were available to them. For hawks, owls, and deer, forests are essential; for woodpeckers, bluebirds, and raccoons, hollow trees are needed; for rabbits, briar patches and brush piles; for woodchucks, stumps and piles of stones; for pheasants, brushy cover; and for muskrats, marshes. These favourable conditions were destroyed in many places when forests were cut, marshes drained, and wire fences installed where there had been stump fences or rail fences in rows of trees and shrubs.

Although we cannot return to the original conditions and restore wildlife as it once existed, we can do much to provide the remaining wildlife with more favourable habitats.

Wildlife Needs Shelter, Food, and Water. Like ourselves and our domestic animals, wild animals need some kind of protective cover under which to escape from their enemies, take shelter from winter cold and summer heat, rear their young in safety, and travel from place to place without fear. Grouse

and deer find safety, comfort, and food in a wood with a tangle of young trees and shrubs. Cottontail rabbits are happy where there are hedgerows, woody thickets, and brush heaps. Trees, shrubs, weeds, and long grass along fences, streams, and ditches make these habitats favourable for many forms of wildlife.

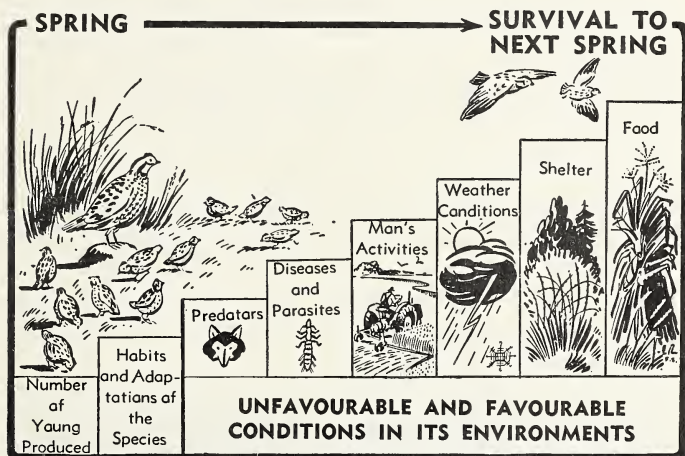


FIG. 22-6. CONDITIONS THAT DETERMINE THE POPULATION OF ANY SPECIES OF WILDLIFE.

Wildlife needs food, preferably close to its protective cover. Nearly 100 species of birds feed on sumach berries. Many birds relish the fruits of each of these plants: wild plum, wild cherry, thorn-apple, bitter-sweet, wild grape, mountain ash, elderberry, Virginia creeper, honeysuckle, wild raspberry, and wild blackberry. Seed-eating birds devour the seeds of trees and weeds. Leaves, buds, and bark are eaten by mice, rabbits, beavers, and porcupines. Marsh plants are food for muskrats.

Wildlife needs water. Animals that live near streams have no difficulty in this regard except when the streams dry up in summer. Songbirds come to our bird baths for water. Animals that eat berries and fleshy fruits obtain much of the water they need with their food.

All these needs of wild animals—protective cover, food, and water—should be kept in mind when we plan to improve their habitats.

Making Land Produce More Useful Wildlife. Wildlife is a crop. Like other crops, it is a product of the soil and water, for soil and water make possible the green plants that feed all other living things. As we learned in chapter 7, meat-eating animals feed upon plant-eating animals, and these, in turn, feed upon green plants. Therefore, the extent to which wildlife will thrive and multiply will depend upon how we use the land to grow plants.

Wildlife is one of the easiest crops to grow. If we allow waste land that is too stony, too rough, too hilly, or too wet for cultivation to produce trees, shrubs, grasses, and weeds, these will provide cover and food for wildlife. Eroded hillsides, swamps, the sides of drainage ditches, gullies, and the uncultivated land along fences will all grow plants useful to wildlife and, therefore, useful to us.

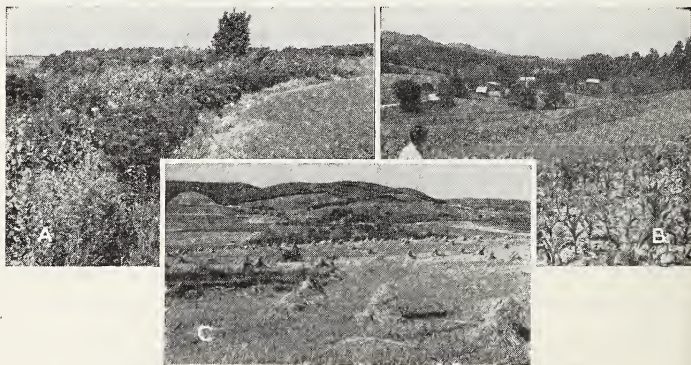


FIG. 22-7. GOOD FARM PRACTICES THAT HELP WILDLIFE.

- A. Once a gully, now a dense growth of shrubs, trees, and smaller plants.
- B. A rural area suitable for wildlife. Find: the roadside bordered with trees and shrubs, the wooded hilltops and slopes, and the field with contour strip cropping.
- C. A typical rural area in New Brunswick. Find: the wooded hilltops; the stream in the centre, bordered by trees and shrubs; the patch of uncut grain at the left, where birds may feed.

Good farming practices and wildlife go hand in hand. It pays farmers to make wildlife at home on their farms. Songbirds will devour myriads of harmful insects and weed seeds; hawks and owls will destroy mice and other rodent pests; skunks will eat insects that attack crops; muskrats will produce valuable furs. Several good farm practices that provide cover and food for wildlife and, at the same time, improve the soil and help to produce bigger crops are described in the accompanying table.

Good Farm Practices That Help Wildlife

Good Farm Practices	Benefits to the Land and to the Farmer	Benefits to Wildlife
Growing wild fruit trees, shrubs, tangles of grapevines, smaller plants, and tall grasses in fence rows (fig. 22-8)	Reduces erosion by wind, and stops run-off water	Provides protective cover where wild songbirds and other animals may rest, sleep, feed, travel, and raise their young in safety
Growing hedges and windbreaks between fields and across the direction of prevailing winds (<i>General Science</i> , Book 1, pages 299-300)	Hedges make good fences to retain stock; the trees and shrubs break the force of the wind, reduce wind erosion, and protect crops	The trees and shrubs provide shelter and nesting places for birds that feed on weed seeds and insects in adjoining fields, also homes for rabbits and chipmunks; evergreen trees give winter protection
Leaving trees and other vegetation on hillsides and other areas not easily cultivated; growing grain and other wildlife food in small waste areas	Produces a worthwhile crop on land otherwise wasted; reduces erosion by wind and water; prevents gullies; conserves water from rain and snow	Provides food and protective cover for such wildlife as songbirds, game birds, and skunks; helps to keep the water in streams clear and more healthful for fish
Contour cultivation and strip cropping (<i>General Science</i> , Book 1, pages 343-344)	Conserve water and prevent erosion	Grass-covered strips provide nesting sites for birds, keep silt from polluting nearby streams and making the water unfit for fish

Good Farm Practices	Benefits to the Land and to the Farmer	Benefits to Wildlife
Maintaining wood lots in good condition (<i>General Science</i> , Book 1, pages 295-299)	Produces wood; conserves soil and water; protects nearby crops from wind	Same values as forests to birds and other wildlife: protective cover, homes, and food
Planting the sides of drainage ditches with shrubs and other vegetation	Prevents water from eroding the banks and filling the ditches; keeps the water clear	The plants provide protective cover, home sites, and food for birds, muskrats, raccoons, and minks
Planting trees and shrubs in gullies, then fencing them in	Conserves water; reduces erosion; attracts birds that eat insects harmful to crops.	Provides protective cover, home sites, and food for such beneficial wildlife as skunks, and birds that feed on insects and weed seeds
Conserving or restoring marshes	Conserves water for crops by raising the water table (<i>General Science</i> , Book 1, pages 114-115)	Provides homes and nesting sites for such wildlife as muskrats, herons, and red-winged blackbirds; helps fish by keeping streams flowing all summer
Making farm ponds, surrounded by trees, shrubs, and vines, and fenced to keep stock out (<i>General Science</i> , Book 1, pages 123-124)	Conserves water for stock; helps crops by keeping the water table higher	Provides homes for fish, muskrats, and water birds; grows minute plants that become the first link in a food chain consisting of tiny plants, tiny animals, water insects, fish, and man
Making and placing bird homes, feeding stations, and water devices	The birds attracted control harmful insects and mice	Protects and attracts beneficial birds; creates right attitudes towards wildlife



FIG. 22-8. FENCE ROWS THAT HELP WILDLIFE.

The fence rows on this farm contain enough trees, shrubs, and smaller plants to provide shelter, nesting sites, and food for many kinds of wildlife. Name all the animals you can in the drawing.

Making Forests Better Places for Wildlife. A forest in good condition provides safe home sites, protective cover, and food for many kinds of wildlife. Woodpeckers and a host of songbirds such as warblers live there and feed on insects from wood, bark, and foliage. Raccoons and squirrels make use of hollow trees, and skunks, foxes, and woodchucks burrow among the roots of trees.

The greatest enemy of forests, and of all living things in them, is fire. It destroys or drives away all wildlife and leaves a desolate waste not fit for habitation for many years to come.

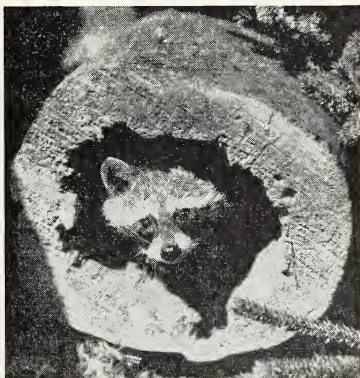


FIG. 22-9. A RACCOON LOOKING OUT FROM HIS HOLLOW-LOG HOME.

To protect forests from fire is one of our first duties to wildlife.

To be of most value to the wild animals that live in it, a forest should have several kinds of trees to produce a variety of nuts and other edible fruits. Hollow trees, logs, and stumps should be left to provide homes for owls, woodpeckers, raccoons, squirrels, and bats.

A thick border of shrubs along the margin of a wood provides shelter, nesting places, and food for wildlife. By breaking the force of the wind, such borders moderate the climate within the woods, benefiting the trees as well as the wild animals living among them. Woodland edges containing such trees as sumach, wild cherry, and dogwood provide acceptable food for birds. Because the birds living in the shrubby border of a forest are close to cultivated land, they are more likely to devour weed seeds and insects in fields and crops.

Improving Waterways for Fish and Other Animals. Fish thrive in streams in which the water is cool and clean and flows freely throughout the year. We can help to maintain these conditions by (1) keeping streams shaded by trees and shrubs growing along their banks, (2) preventing the water from becoming polluted, and (3) conserving water in the areas drained by the streams.

Keeping Banks of Streams Wooded. The banks of a stream are usually covered by a dense growth of trees and shrubs unless man has cut them away. The foliage of these shades the water and keeps it cool; their roots anchor the soil on the sloping banks, preventing it from being worn away and polluting the stream. Bare streambanks can be wooded again by planting such water-loving trees as willows and alders (fig. 22-10). A dense growth of trees along the banks of a stream makes ideal living quarters for songbirds, game birds, and fur-bearers by providing them with cover, food, and water close together.

Keeping the Water in Streams Clean. Our streams would contain more fish and better fish if we could keep the water in

them from being polluted by silt from farm land, sewage from man's settlements, and chemicals from industries.

The amount of silt carried into streams by water from cultivated fields can be reduced by such good methods of farming as: growing trees or grass on hillsides and slopes, contour cultivation, strip cropping, and stubble-mulch farming (*General Science*, Book 1, pages 340-347).

When sewage and waste from mines, pulp-and-paper mills, and other industries enter streams, they frequently poison fish and other living things on which the fish feed. The pollution of streams by sewage is prevented when cities and towns build sewage disposal plants to destroy the disagreeable odours and disease germs in sewage. Most large industries are continually looking for new ways of using their waste products instead of disposing of them in nearby streams. In other ways, laws and regulations, and the co-operation of factory owners, are helping gradually to prevent streams from being polluted by such wastes.

Keeping Streams Flowing Freely All Year. Forests and marshes store up water in spring and feed it out gradually to streams throughout the summer. Dams made by beavers and by man serve the same purpose. Many streams that flowed the year round from the original forests, but dried up

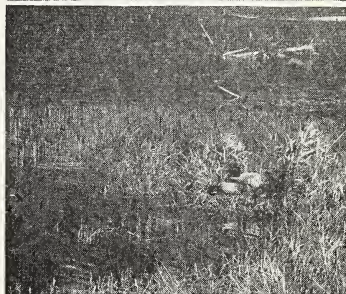


FIG. 22-10. IMPROVING WATER HABITATS FOR WILDLIFE.

Top, willows growing on streambanks; middle, a valuable and attractive farm pond; bottom, a common loon nesting in a well conserved marsh.

in summer after the forests were cut, have been made to flow again throughout the year by the planting of new forests—and the water in them is again cool enough and clean enough for fish.

Dams built across streams to develop hydro-electric power or to help in the construction of railways and highways may make waterfalls that are too high for salmon to pass over on their way upstream to lay their eggs. As a result, the fish die without laying eggs, and no young salmon are produced in that stream. Fortunately, engineers can help the salmon by building *fish ladders* (fig. 22-11) in or beside high dams. Each fish ladder is like a stairway in which each step is a pool of water, and each pool is close enough to the next for fish to jump easily from one to the other.



FIG. 22-11. THE LARGEST FISH LADDER IN THE WORLD.

More than half a million fish, mostly salmon, ascend this and other fish ladders in the Columbia River annually.

Conserving Marshes for Wildlife. Marshes are the natural habitats of muskrats, some water fowl, and such songbirds as red-winged blackbirds. For these the cattails and other plants provide shelter, nesting sites, and food. If the plants are to grow well, marshes must contain a few inches of water all summer. The water must be so deep in winter that muskrats can swim beneath the ice. Marshes remain favourable habitats for wildlife

only so long as they are not drained, grazed, or burned over. See fig. 22-10, bottom.

In northern Manitoba large areas of marshland that were once drained have been restored by building dykes and dams. In three years muskrat houses became nearly 200 times as numerous in these new marshes.

“Let us remember that Canada has more fresh water than any other land on earth—and let us manage our waters, big and small, to produce fish and fur and water-fowl crops, worth millions, and provide vital moisture for our thirsty soil.”

From “Our Feet on the Ground”

We Can Replenish Diminishing Wildlife

Streams in which game fish are scarce are often restocked with young fish from fish hatcheries. Female and male fish are

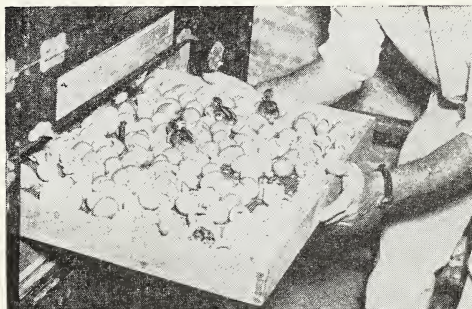


FIG. 22-12. WATER TANKS IN A FISH HATCHERY.

These trout fry are about two months old.

caught and taken into captivity. Eggs are squeezed from the female fish, then fertilizing milt is squeezed from the male fish over the eggs to fertilize them. The fertilized eggs are stored in fresh water until they hatch. The young fish (*fry*) are fed and cared for in tanks of cool, fresh water until they are large enough to look after themselves when placed in streams. See fig. 22-12.

FIG. 22-13. PHEASANTS HATCHED FROM EGGS IN AN INCUBATOR.



Thousands of young pheasants are hatched in incubators in Ontario each year (fig. 22-13). When these are a few weeks old, they are turned loose where they can find shelter and enough food of the kinds they like.

Such wildlife as elk, deer, beavers, and muskrats are often transferred from areas where they are plentiful to new areas where they are few in number, but where the conditions are favourable for them.

We Should All Help To Conserve Wildlife

Wildlife will have its rightful place in woods and streams, on farms and roadsides, and around our homes only if everyone helps to conserve it. Everyone includes farmers, trappers, hunters, fishermen, foresters, and, of course, you and me.

Listed below are several ways in which we learn to understand better the ways of wildlife and to help to conserve it.

1. Refrain from needlessly harming a snake, a toad, a worm, or any other harmless living thing.

2. Be careful with fires when camping or hiking in woods or grasslands, and take every opportunity to help to prevent forest or grass fires.

3. Be an active member of some bird club or nature club, perhaps in your school, organized to help people understand and protect wildlife.

4. Show that you are a true sportsman by respecting all fish and game laws and regulations, and the officers who enforce them, knowing that both work in your interests.



FIG. 22-14. SIGNS TO BE RESPECTED.

When we read signs like these, we should remember that those who planned and made them are giving us good leadership in preserving our wildlife, both for ourselves and for others.

5. Provide birds with feeding stations, water baths, nesting boxes, and nesting materials.

6. Plant trees and shrubs that will provide food and shelter for birds.

7. Set up a conservation corner in your classroom.

Excursions To Study the Protection of Wildlife

Places To Visit	What To See	Things To Do
Pastures, meadows, fence rows, streams	<p>Birds eating weed seeds and insects</p> <p>Trees and shrubs bearing fruits that birds eat</p> <p>Vines, shrubs, and thorny plants that protect game birds, songbirds, rabbits, and other wildlife from their enemies</p>	<p>Plan ways of making the surroundings better habitats for wildlife</p> <p>Encourage a farmer to leave shrubbery and other vegetation in fence rows to give food and protection to wildlife</p>
Woods	<p>Nests, hollow trees, burrows, and other kinds of homes for wild animals</p> <p>Whether there is a dense growth of shrubs around the edges of the woods</p> <p>Whether undergrowth of trees and shrubs is destroyed by grazing animals</p>	<p>Make sketches of homes of wildlife</p> <p>Dig into the forest floor and examine the black, decayed vegetation which conserves water</p> <p>Discuss methods of improving the forests for wildlife</p>
A wildlife refuge	<p>What birds and other wild animals live there</p> <p>How they are protected</p> <p>How birds are protected from cats and other enemies</p>	<p>Make sketches of nesting boxes, bird feeding stations, and bird baths</p> <p>Discuss how your school grounds may be made into a bird refuge</p>

Things To Do

1. For your classroom library, write to Canadian Wildlife Service, Department of Resources and Development, Ottawa, for leaflets and booklets dealing with the conservation of wildlife.

2. Interview elderly citizens to find out what wild animals have disappeared or have become scarce in your community, and why.

3. Invite a game warden to discuss with you in class the best methods of improving conditions for wildlife in your community.

4. Find out what the following fur-bearers eat, then decide what good and what harm they do: foxes, skunks, minks, weasels, raccoons, muskrats, woodchucks.

5. Discuss in class how forests, soil, water, wildlife, and men depend on each other.

6. Set up a balanced aquarium in your classroom. As a guide, see *General Science*, Book 1, the appendix.

7. Plan a wildlife week at school, with a programme that will help to make people in your community more conscious of the need for and the methods of conserving wildlife.

8. Make an outline map of your province and locate on it some national and provincial parks, fish hatcheries, and bird sanctuaries.

9. Make posters to serve one or more of the following purposes: to encourage people to protect birds; to show that hawks and owls are beneficial; to illustrate safe resting and feeding places for migrating water fowl; to suggest to people that wild flowers should be protected.

10. Make bulletin board displays of pictures to illustrate some of these: wild flowers that should not be picked; wild animals that need protection; homes of wildlife; migratory water fowl; commercial and game fish; mammals of our national parks; enemies of wildlife; methods of protecting wildlife.

Test Questions

1. In what ways may each of the following be enemies of wildlife: people, weather, forest fires, diseases, other animals?

2. How do good management of existing forests and the planting of new forests help wildlife?

3. Why do farmers drain swamps and marshes? How does this harm wildlife?

4. What can be done with the following to make them better habitats for wildlife: vacant lots, fence rows, waste areas, parks, roadsides, schoolgrounds?

5. How do beavers prevent floods, conserve water, and prevent erosion by water?

6. What kinds of wildlife are deprived of homes by (a) draining swamps and marshes; (b) cutting forests; (c) clearing shrubs and other vegetation from fence rows?

Your Word List

Conservation, wildlife, depleted, habitat, protective, contaminated, exterminated, sanctuaries, refuge, migratory, environment, contour, windbreak, fence row, waterways, polluted, hatcheries, fertilize.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "Conservation—the Wise Use of Natural Resources", Vol. C, pp. 451-456; "Protecting and Conserving Our Birds", Vol. B, pp. 190-196; "The Buffalo—Monarch of the Plains", Vol. B, pp. 198-201; "A Favourite among Birds the World Over—the Duck", Vol. DE, pp. 158-162; "Playing 'Nursemaid' to Young Fish", Vol. F, pp. 110-112; "Playgrounds of Two Nations", Vol. NO, pp. 19-29.

16 mm. Sound Films

Ontario Visual Education Branch

Buffalo Lore (colour) (SN-83)

A Fish Is Born (SN-28)

Life on the Western Marshes (ducks and geese) (colour)
(SN-104)

National Film Board of Canada

New Homes for Beavers

Your Forest Heritage (colour)

Look to the Forest

Tomorrow's Timber (colour)



UNIT TEN

Farm Animals Are Man's Helpers

23. *LIVESTOCK: THE BASIS OF GOOD FARMING*

The raising of livestock is one of the most important phases of agriculture. From the livestock industry we derive food, wool, leather, and many other useful products. By careful selection and scientific breeding, man has developed stronger breeds of draft horses, more productive breeds of cattle, hogs that produce better bacon, and sheep from which high-grade wool is obtained. The value of the livestock industry in Canada constantly increases as improved methods of caring for and feeding livestock are discovered and used.

24. *POULTRY AND EGGS*

The fowl raised on our farms today were developed from wild fowl that lived in various parts of the world. As the number of people living in towns and cities increased, more and more poultry farms were established to provide the eggs and meat required. At the same time, egg production was increased as poultrymen developed better methods of selecting, housing, and feeding fowl. Modern methods of grading and marketing eggs and fowl have proven beneficial to both the poultryman and the consumer.

23

LIVESTOCK: THE BASIS OF GOOD FARMING

LIVESTOCK IS RAISED ON MOST FARMS. Horses, cattle, and hogs are the most common; sheep are found on fewer farms today. Many farmers specialize in raising livestock of one or more kinds: cattle, hogs, sheep, or horses. On other farms only enough livestock is raised to meet the needs of the farmer and his family.

Values of Livestock

Livestock on a farm changes plant materials into meat, milk, and other products used by man. The value of the pork, beef, lamb, or mutton produced by livestock is much greater than that of the hay, grain, and hoed crops consumed in their production. Much of the feed of livestock consists of farm products that would otherwise be wasted. Although hogs are fed much grain, they also feed upon skim-milk, buttermilk, and whey, a by-product of cheese making. Beef cattle obtain much of their food from grass grown on stony, hilly, or low-lying land. Sheep feed to a large extent on the vegetation of steep hillsides and of other land too rough for cultivation.

The livestock industry satisfies many of our daily needs. Live domestic animals provide us with milk and milk products, wool

for clothing, and labour with which to earn a living. The flesh of slaughtered farm animals becomes one of our most nourishing foods. The hides of horses and cattle become our shoes, traveling cases, and gloves. Even the fat, bones, and blood of livestock produce such useful by-products as lard, soap, buttons, and fertilizer. The value of livestock sold from Canadian farms exceeds the value of all hay, grain, fruits, and vegetables sold.



FIG. 23-1. HAY IS GOOD FEED FOR CATTLE.

Livestock helps to keep farm soil fertile. The hay, grain, and other plant crops grown on a farm take valuable plant foods from the soil as they grow. When these feeds are consumed by livestock, a large part of the plant foods, undigested by the animals, is returned to the soil as manure. This fertilizes the soil by returning some of the plant foods to it. Thus, the raising of livestock on a farm helps to keep its soil fertile and highly productive.

Livestock contributes largely to Canada's national wealth. It provides the raw materials for meat packing, wool processing, and leather tanning and manufacturing. Thus, the livestock industry gives employment to thousands of men engaged in

transportation, manufacturing, and selling. In these ways, livestock plays an important part in making Canada a prosperous nation.

Horses

The Story of the Horse. It is hard to realize that the horse, as we know it today, has been developed from a forest-dwelling animal about the size of a small fox or a collie dog. As centuries passed, these first little horses became bigger and stronger, and were eventually tamed and developed by man. Wild horses still roam on the grasslands of Central Asia. These are about four feet high and have clumsy heads, small eyes, and short, erect manes.

It is believed that the Arabs were among the first people to tame wild horses to be their servants, especially in war. They bred a fine type of horse, from which some of our best breeds have been developed. For speed, we now have trotters, pacers, and saddle horses; for performing heavy duties, draft horses.

Characteristics of Draft Horses. The most important work of horses today is to haul loads or farm implements. Those fitted for this work are called *draft* horses. Their usefulness depends largely upon their weight and muscles. The weight of a draft horse should be 1,600 pounds or more. To be able to do heavy work, it has to eat and digest large quantities of feed and, therefore, it must have a well-rounded-out and deep body. One usually speaks of a horse as pulling a load, but, in reality, it is pushing against the collar fitted to its shoulders. To move a load in this manner, it must have sloping shoulders, well-muscled hind quarters, and a strong, muscular back. A horse that has all these characteristics is an excellent type of draft horse.

Common Breeds of Draft Horses.

PUPIL INVESTIGATIONS.

Find and list the names of breeds of horses common in your community. Study fig. 23-2. For what kind of work is each breed used? What breed is most popular?

The *Clydesdale* horse originated in the Clyde river district in Scotland. Its large, strong feet and legs make it a good draft type. The back of the leg is covered with fine hair, commonly known as "feather". Clydesdales are usually bay, brown, or black in colour, with white feet and a white star or stripe on the face.

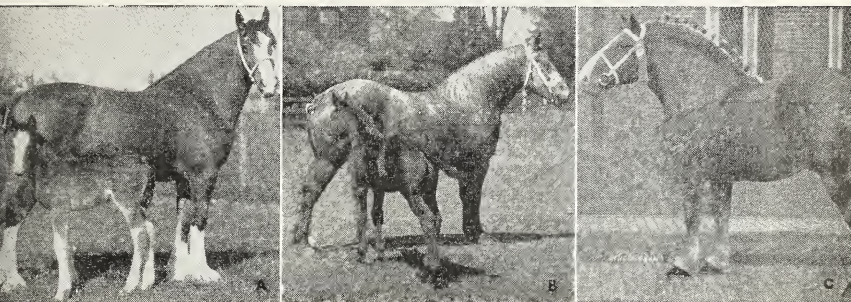


FIG. 23-2. THREE POPULAR BREEDS OF DRAFT HORSES.

A, Clydesdale; B, Percheron; C, Belgian.

The *Percheron* horse was developed in the La Perche district of France for drawing stage coaches. With the coming of the railway and the motor car, this breed became popular for draft purposes. Percheron horses are very compact and blocky in form, are well-muscled, and have no "feather". Grey and black are the most common colours of this breed.

The *Belgian* horse is usually thicker-bodied than either the Percheron or the Clydesdale. Most horses of this breed are either chestnut or roan in colour. Belgian horses are more common in the Province of Quebec and in some of the Prairie Provinces than elsewhere in Canada.

Two other draft breeds, the *Shire* and the *Suffolk Punch*, both of English origin, have failed to meet with much favour in Canada.

Feeding and Caring for Horses. The usefulness of a horse is determined, to a considerable extent, by the manner in which

it is fed. Oats, bran, and clean mixed hay are the most satisfactory feeds for horses. A little salt is essential. Water should be given before each meal.

The care given a horse also affects its usefulness. A horse cannot be expected to work satisfactorily if its harness, especially its collar, does not fit properly. Horses that are working on pavement or gravel should be kept shod. All idle horses should have exercise. Whether horses are working or not, they should be groomed night and morning.

Review Exercises

1. What are the characteristics of a good draft horse?
2. Make a table, somewhat like the one suggested below, to summarize what you have found out about draft horses.

Draft Horses

Breed	Origin	Characteristics

Cattle

Cows are mentioned in records dating back nearly 10,000 years. When Marco Polo was in China, he found dairy products, and cattle which were "well-sized, fat, and exceedingly handsome". Perhaps the cattle brought by Columbus to America in 1493 were the origin of the herds of wild cattle later found on the western plains. For centuries, man has raised cattle to satisfy many of his needs.

PUPIL INVESTIGATIONS.

1. Find and list the names of the breeds of cattle raised in and near your community. Display a picture of each breed, and state whether it is raised chiefly for milk or for beef. What breed is the most common? Why?
2. What cattle feeds are used in your district? Which are grown locally? Where are the others obtained?

From the wild cow two main types of domestic cattle have been developed, the *dairy type* and the *beef type*. In developing dairy cattle, milk-producing capacity has been stressed. The beef type of cattle is well fitted to produce a large amount of good beef. A third type, the *dual-purpose type*, has been produced to serve both purposes.

Dairy Cattle Type. Dairy cattle are bred and kept for the production of milk. A well-formed dairy cow appears rather lean of flesh and somewhat angular of frame, the body being narrower at the front, and widening towards the rear. This shape resembles a wedge, and is in contrast to the blocky shape of a beef-producing animal.

To produce large quantities of milk, a dairy cow must be able to consume and digest large quantities of food. That she can do so is indicated by well-developed hind quarters, good depth of body, and wide spread of ribs. The udder of a good milking cow should be large and evenly balanced, with the teats evenly placed in the four

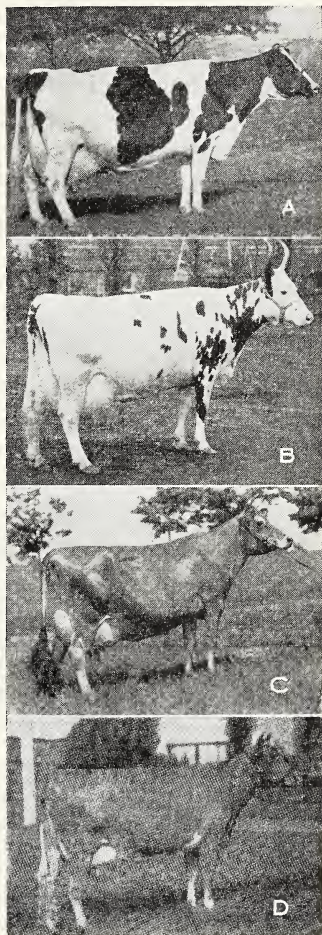


FIG. 23-3. BREEDS OF DAIRY CATTLE. A, Holstein-Friesian; B, Ayrshire; C, a Jersey cow reared at Brampton, Ontario, and holder of the world's record for production of butterfat; D, Guernsey cow, grand champion at the Canadian National Exhibition.

quarters. The quality of the dairy cow is also shown in the softness of the skin and the fineness of the hair.

Breeds of Dairy Cattle. *Holstein-Friesian Cattle.* The Dutch were pioneers in cattle breeding. As early as the time of the Roman Empire, the region now called Holland was noted for its black and white cattle and its cheese. From there has come the most popular and profitable dairy breed in Canada, the Holstein-Friesian, commonly called the Holstein. This breed is recognized by its black and white colours and its very large size. Although the milk given by cows of this breed is the most plentiful, it is the least rich in butterfat.

Ayrshire Cattle. This breed was developed in Scotland and takes its name from the County of Ayr. Ayrshire cows can be recognized by their distinctive brown spots or patches on a white background. This breed produces richer milk, but less of it, than does the Holstein.

Jersey Cattle. For the past 1,000 years the people of the Island of Jersey (in the English Channel) have been improving their cattle, and, as a result, the milk of the Jersey cow now stands first in richness, colour, and mineral content. Unfortunately, this small cow gives the least milk of all dairy breeds. Although the commonest colour for Jersey cattle is fawn, the tone may vary from silver-grey to dark brown.

Guernsey Cattle. From Guernsey Island, also in the English Channel, comes another breed of cattle, the Guernsey—somewhat similar to the Jersey. In colour this breed is generally fawn with white markings. Guernsey cows give more milk than Jerseys, but it is not as rich.

Beef Cattle Type. The raising of beef cattle is profitable because the animals are so well fitted to change pasture, grain, and fodder into flesh which can be sold as beef. To serve this purpose best, the animal should have a smooth, compact, rectangular body, with straight sides, and with the top and bottom lines parallel. There should be good depth and width, thick hind

quarters, and short legs and neck. Over the whole body there should be a thick, even layer of flesh.

Breeds of Beef Cattle. *Shorthorn* cattle, as the name indicates, have comparatively short horns. The colour may be red, white, roan (a mixture of red and white hairs), or spotted red and white. The dual-purpose Shorthorn has been developed to produce both milk and beef fairly well. It is not as efficient a producer of beef as the beef type of Shorthorn, nor as efficient a producer of milk as breeds of dairy cattle.

Hereford cattle have comparatively long horns. These cattle are red in colour, with a white face and tail switch, and with some white on the neck and underparts. Hereford cattle are especially well adapted for feeding on pasture, but they also do well when fed on fodder and grain.

Aberdeen Angus cattle, originating in Aberdeen County, Scotland, have no horns and are almost entirely black in colour. At maturity they are not quite as heavy as the other beef breeds, but their carcasses are excellent for small cuts of high-grade beef. This breed of beef cattle grows well when given stable feed.



FIG. 23-4. BREEDS OF BEEF CATTLE.

A, Shorthorn; B, Aberdeen Angus; C, Hereford.

Care of Cattle. To be profitable as producers of either milk or beef, cattle must be given enough of the right kinds of feed, plenty of fresh water, and comfortable living conditions. Beef cattle may be fed either on pasture or in the stable. Because grain is essential for fattening cattle, it is common practice to

feed them on pasture in summer and fatten them in the stable in autumn or winter. All cattle should be housed in a clean stable, free from drafts, and with good ventilation and direct sunlight. When indoors, cattle should have a bed of clean, dry straw.

Things To Do

1. Name the two main types of cattle and the chief breeds of each type raised in Ontario.
2. How do beef cattle differ from dairy cattle in (a) general appearance, (b) shape, (c) amount of flesh?
3. Plan and make two tables to summarize the identifying features and the characteristics of three common breeds of (1) dairy cattle and (2) beef cattle.

Hogs

The first domestic pigs were developed from wild ones in China more than 4,000 years ago. Wild hogs still roamed the forests of England at the time of William I. Although hogs like to wallow in a mud bath to protect their bodies from vermin, they are among the best of animal housekeepers. If given straw or grass, they will make neat beds for themselves and their young, and keep them clean, too. They grow best when they can get pasture or green feed in addition to ground grain. Hogs are now raised in every grain-growing country of the world. Because hogs can be raised at lower cost than most other farm animals, they have been called the "mortgage lifters" of the farm.

Two types of hogs have been developed, the *bacon type* to produce bacon chiefly, and the *lard type* to produce fat. The first finds a ready demand on the English market; the second is popular where corn, an excellent fattening food, is grown in large quantities. Both the demand of the British market for bacon, and the kinds of feed grains and dairy by-products available in Ontario, make the bacon type the most profitable for farmers of that province.

Bacon Hog Type. Bacon comes from the sides and back of a hog carcass. For this reason, the most suitable type of hog to produce quality bacon is one with long, flat, deep sides, and a wide back of uniform width (fig. 23-5,A). The flesh should be firm, and the hog should weigh about 200 pounds when slaughtered.

Breeds of Bacon-Type Hogs. The three common breeds of bacon-type hogs are the Yorkshire, the Tamworth, and the Berkshire.

The *Yorkshire* hog is white in colour and is the largest and best bacon hog. It produces a very high quality of bacon having an even distribution of fat and much lean meat.

The *Tamworth* hog is red in colour, slightly smaller than the Yorkshire, and tends to have too much fat.

Berkshire hogs are black, and have white on the face, legs, or tail. Their dark skin and short length makes them less desirable bacon hogs than either the Yorkshire or the Tamworth breeds.

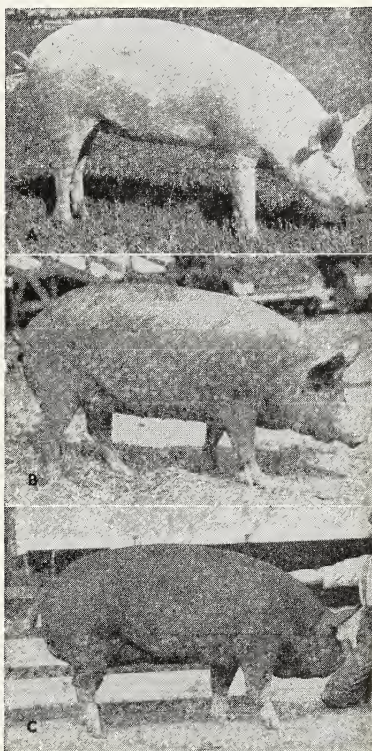


FIG. 23-5. BACON-TYPE HOGS.

A, Yorkshire; B, Tamworth; C, Berkshire.

Answer These

1. Why are the hogs raised in Ontario chiefly of the bacon type, while those raised in the corn belt of the United States are chiefly of the lard type?

2. What are the main characteristics of a bacon-type hog?
3. Name the chief breeds of hogs raised in your part of Canada.

Sheep

Centuries before the birth of Christ men raised sheep for their hides, wool, and mutton. During the early days of Canadian agriculture most settlers established little flocks of sheep to supply both food and clothing for their families. A few generations ago most Canadian farmers still raised sheep for their wool, with which they made their own garments and blankets. Although fewer farmers attempt to raise sheep today, and these usually in small flocks, sheep raising could be an important branch of Canadian agriculture.

The Habits and Care of Sheep. The most interesting habit of sheep is their tendency to follow a leader. The well-beaten paths in old sheep pastures, such as those in the highlands of Scotland, show this.

Under the right conditions, sheep can be raised cheaply and profitably. Because they can crop grass more closely than most farm animals, and seem to enjoy even weeds, they can live in summer on rough land having comparatively poor pasture. But to grow well, they need good grass and, better still, some grain, too. Although sheep can withstand more severe winter conditions than horses or cattle, they should be housed well enough to keep their wool dry. They require fresh water, grain, and plenty of rough feed such as hay and straw.

Some Common Breeds of Sheep. Some kinds of sheep are best suited to produce meat, and are therefore classed as *mutton-type* sheep. Like beef cattle, they should be deep, broad, and low-set. Sheep raised chiefly for their fine wool are known as *wool-type* sheep. Though most of the sheep raised in Ontario belong to the mutton type, their wool is of considerable importance.

PUPIL INVESTIGATIONS.

Find what breeds of sheep are raised in your community. Collect and arrange pictures of these.

Mutton-type Sheep. Sheep of the mutton type are classified as *medium-wool* sheep and *long-wool* sheep. Those of the first class produce the better wool.

Among the medium-wool sheep the four commonest breeds, particularly in Ontario, are the Oxford, the Shropshire, the Southdown, and the Hampshire. Study fig. 23-6 as you read this. The *Oxford* (A) is the largest, but has coarse wool. The front legs, ears, and lower part of the face are covered with dark grey or brown hair. The *Shropshire* (B) is smaller than the Oxford, and has finer wool, extending almost to its dark brown nose. The *Southdown* (C), smaller even than the Shropshire, and with very short wool on the face, produces excellent mutton. The *Hampshire* (D) is known by its large size, the dark hair on its face, ears, and legs, and the fact that its ears stand straight out.

The most common long-wool sheep in Ontario is the *Leicester* (E). Its wool grows in long ringlets, and its face and legs are bare and white. *Lincoln* and *Cotswold* sheep are also long-wooled.

Wool-type Sheep. The *Merino* and *Rambouillet* sheep, both of Spanish origin, yield very fine wool, but they have not become popular in Canada.

The Importance of Wool. For two reasons, wool is perhaps the most important fibre for textiles. First, the fibres are easily spun and woven together because of the tiny scales covering them.

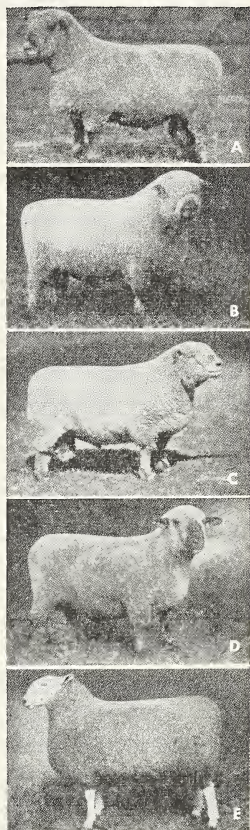


FIG. 23-6. COMMON BREEDS OF SHEEP.

A, Oxford; B, Shropshire; C, Southdown; D, Hampshire; E, Leicester.

Second, the air imprisoned among these fibres causes woollens to retain heat well. Because wool fibres are elastic, woollen garments retain their shape well. Although woollens are light, soft, and rich in appearance, they are also strong and durable.

Things To Do

1. Investigate and describe to your class the manufacture of wool from the time it is sheared from the sheep until it becomes a woollen blanket or a piece of worsted cloth.
2. Discuss in class the advantages and disadvantages of raising sheep in your community.
3. Obtain samples of woollens and of other fabrics. Try to burn each. How does wool differ from the others in the ease with which it burns, and in the resulting odour?

How Man Improves Livestock

Ever since man first tamed and domesticated wild animals to become his livestock, he has been making them more useful to him. He has also developed many new types and breeds. From wild cattle he has developed beef cattle and dairy cattle, each type well adapted to serve its special purpose. From the first small, wild horses have come the sturdy draft type, well fitted to pull heavy loads, and the race horse, characterized by speed and endurance.

Livestock is classified as *pure-bred*, *grade*, or *scrub*. A pure-bred animal is the most highly improved of farm animals. To be classified as pure-bred, an animal's ancestors must have been of the same breed for several generations. A record of the ancestors of any animal is called its *pedigree*. This record is kept by an organization dealing only with animals of that breed. The organization gives the owner of an animal a registration certificate which shows the animal's pedigree and certifies that it is pure-bred.

A *grade* animal is not registered, and cannot be. Usually one of its parents is pure-bred and the other is of mixed breeding. Grade animals may be so well bred that they look like pure-bred

animals and serve their owners just as well, but, since we do not have any record of the ancestors of grade animals, we cannot judge very well what their young will be like.

A *scrub* animal is the product of poor breeding and poor care. Neither its mother nor its father is a pure-bred animal. Hence, little is known about its ancestors. Likewise, little can be foretold about the quality of its young. Most farmers avoid scrub animals.

Good farmers continually strive to bring about an improvement in their livestock from generation to generation. Whether they are raising horses, cattle, sheep, or swine, they know that the better the quality of the parent animals, the better will be the quality of the young. Therefore, good breeders select the best females they have to become the mothers of young stock. These they mate with high-quality, pure-bred males (sires) of the same breed. In this manner, each generation of livestock becomes better than the preceding one.

Review Questions

1. What is meant by: a pedigree, a pure-bred animal, a grade animal?
2. In what ways does livestock farming keep the soil more fertile than grain growing?

Your Word List

Clydesdale, Percheron, Holstein-Friesian, Ayrshire, Jersey, Guernsey, Hereford, Yorkshire, Tamworth, Berkshire, pure-bred, pedigree.

Read

Compton's Pictured Encyclopedia, 1953 Edition: "The Most Useful of All Domestic Animals" (cattle), "When Cattle Ruled the Western Plains", Vol. C, pp. 141-155; "Man's Friend and Servant, the Horse", Vol. GH, pp. 428-428J.

16 mm. Sound Films

National Film Board of Canada
Cattle Country
Hog Family Supreme (colour)

POULTRY AND EGGS

IN PIONEER TIMES most farmers raised chickens, and sometimes a few ducks, geese, and turkeys. These fowl provided the family with a ready supply of meat and eggs. As cities and towns grew, the demand for both eggs and fowl caused many farmers to specialize in raising poultry.

Wild and Domestic Fowl

Jungle fowl (fig. 24-1), small and brown like Brown Leghorn hens, have lived wild in the forests of northern India

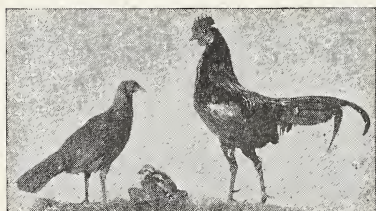


FIG. 24-1. RED JUNGLE FOWL.

and Burma since before man began to record history. Centuries before the birth of Christ, travelling Chinese took some of them home and trained them to live near man's dwellings. Man has also tamed for his use some

wild varieties of ducks, geese, and turkeys and, from these, has developed our modern breeds. Turkeys are native to America and were first tamed and improved by the early American colonists.

Common Breeds of Hens

Throughout the centuries man has continually improved the hen, perhaps more so than any other domestic animal. More than 100 breeds have been developed from the wild jungle fowl, some to produce a maximum number of eggs, others to produce meat, and still others to serve both purposes. Each breed of hen common in Canada serves one of these three purposes and, therefore, belongs to the *egg class*, the *meat class*, or the *dual-purpose class*.

In the egg class, White Leghorns are the most popular. They mature rapidly and become excellent layers, but they are usually too small to be good roasters. In the dual-purpose class, many Barred Rock and New Hampshire Red hens (fig. 24-3) are raised by poultrymen who prefer chickens that

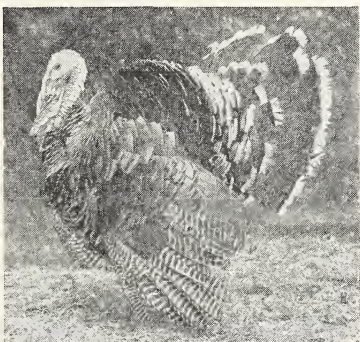


FIG. 24-2. BRONZE TURKEY.

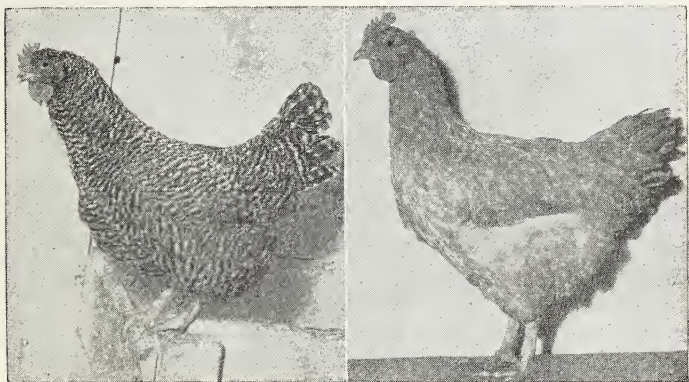


FIG. 24-3. COMMON BREEDS OF HENS.
Left, Barred Rock; right, New Hampshire Red.

lay well and are also large enough to give a good supply of meat. Poultry of the meat class are sufficiently large and heavy to be excellent for meat production, but they lay so few eggs and eat so much feed that few Canadian poultrymen raise them.

Caring for Poultry

Good poultry houses (fig. 24-4) pay well by helping to keep the flock healthy, increasing the number of eggs produced, and reducing the poultryman's labour. The houses should provide plenty of room for the fowl to exercise—about four square feet of floor space for each bird. The window area should be large enough to permit sunlight to reach nearly every part of the floor at some hour of the day, for sunlight improves the general health of the poultry and helps to prevent disease. Cotton screens on open windows provide ventilation without drafts.

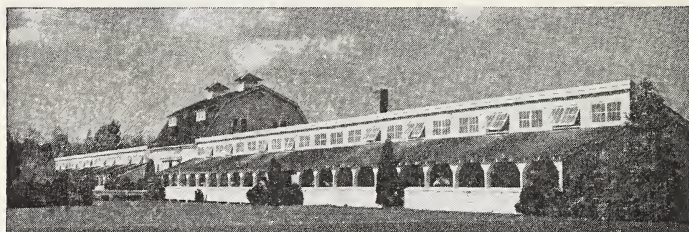


FIG. 24-4. A MODERN POULTRY HOUSE.

This fine building on a poultry farm near Abbotsford, B.C., is well lighted and ventilated and is protected by the windbreak at the left.

The equipment of a good poultry house includes plenty of clean nests, dropping boards under the roosts, troughs and hoppers that make feed available at all times, and fountains for clean water. A dusting box containing dry soil or ashes helps to keep the birds free from lice. The floor should be covered with a deep layer of fine, dry straw or other litter.

Good poultrymen feed poultry well. They provide the right kinds of feed in proportions that will ensure rapid growth, good health, and maximum egg production. Commercially prepared feeds are commonly used now. A constant supply of fresh

water should always be at hand. Grit should be provided to help the hens digest their food, and shell or limestone materials are needed for the growth of bones and the formation of shells on eggs. Animal feeds and green plant materials help to keep the birds well nourished and healthy.

Hens Are Egg Factories

The value of a laying hen to its owner is determined largely by the number and the quality of the eggs it produces. To pay for its feed and give the poultryman some profit, a hen must lay about 150 eggs a year. Good hens lay more than 200 eggs in this time. The number of eggs laid depends upon the breed, the quality of the hen, and the care and feed given.

The Structure of an Egg.

PUPIL INVESTIGATIONS.

Carefully chip the shell from the large end of a fresh egg. Notice the rough, porous nature of the shell. Pierce and tear away a little of the membrane just under the shell and find the air space. The older the egg, the larger this air space will be. Now break the egg and drop the yolk and the white into a saucer. Notice the position and the shape of the yolk. Look for a tiny germ spot on the yolk. This germ could have developed into a chicken. Find all the parts labelled in fig. 24-5.

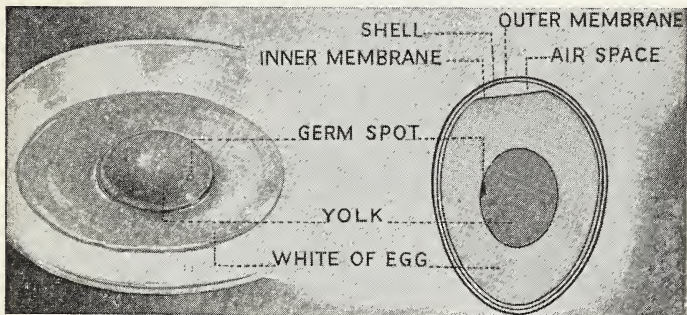


FIG. 24-5. THE STRUCTURE OF AN EGG.

How Eggs Are Formed in the Hen. Young female birds, called pullets, begin laying undersized eggs when four to six

months old. At that time they have inside them many very tiny eggs capable of developing into full-sized ones. If the hen eats and digests more feed than she needs in order to grow and remain healthy, some of it will nourish the tiny eggs, one at a time. The food brought by the bloodstream helps the yolk to develop first. As the egg moves along in the body, the white of the egg is added to the yolk. Lastly, the hard shell is formed from lime (calcium) in the food. Then the egg may be laid. See fig. 24-6.

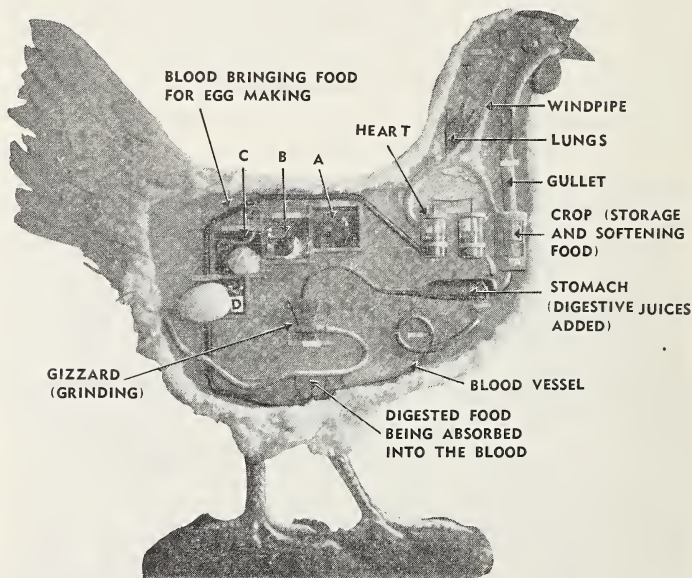


FIG. 24-6. A HEN AS AN EGG FACTORY.

This is a photograph of a "mechanical hen" made to illustrate a "perfect factory". It was examined at a World Poultry Convention by 75,000 people.

A, producing an egg yolk; B, covering the yolk with white of egg; C, wrapping a double membrane around the egg; D, putting the shell on the egg, making it ready to be laid.

Digested food, carried by the blood stream, supplies the necessary nourishment at all stages in the production.

Eggs for Food

Few farm products are as important to us as eggs. We use them as food in many ways, from egg nogs to cake mixes. Several millions of dollars worth of eggs are sold annually in Canada.

Caring for Eggs. The value of eggs is determined by their quality as well as their size. Their quality depends upon the food eaten by the hens, the cleanliness of the nests, the conditions under which the eggs have been stored, and their age. An egg may have an undesirable flavour if it has been stored where there are strong odours, or if the hen that laid it ate too large quantities of such foods as beef scraps, cabbage, and onions. Unless hens' nests are kept clean, the eggs in them are likely to become soiled in appearance and lowered in quality by the action of bacteria that pass through the porous shells.

Eggs should be gathered from the nests soon after they are laid and, unless they are marketed without delay, should be stored in a cool place. Warmth reduces the quality of an egg by increasing the evaporation of moisture through its shell and so causing the air space to enlarge. It also causes an egg to decay slowly by speeding up the multiplication of harmful bacteria that may have entered through the shell. In addition, warmth causes the germ in a fertile egg to begin to develop into a chicken.

Grading Eggs for Sale. The Canadian Government requires that eggs be graded before being offered for sale at a market or a store. This benefits both the buyer and the seller. The buyer can obtain whatever grade of eggs he can afford, and the poultryman who takes precautions to produce eggs of high quality and to care for them well is rewarded by higher prices. The grade of an egg is determined by both its quality and its size.

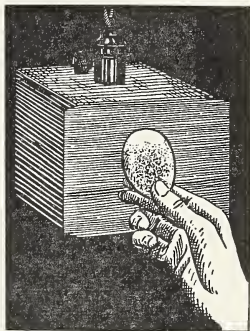


FIG. 24-7.
CANDLING AN EGG.

Eggs are candled to determine their quality. A candling box contains a light and has an egg-shaped hole, slightly smaller than an average-sized egg, in the side. In a darkened room, the egg to be inspected is held in front of, and close to, this hole. As the light inside the box shines through the egg, the observer estimates the size of the air cell and studies the condition of the yolk. A small air cell is evidence of freshness and good care; so is an inconspicuous yolk.

Eggs are weighed to determine their size. The size differs greatly, depending upon the breed of the hen that laid the egg, the maturity of the hen, and its food and health. A dozen eggs from one hen may weigh almost twice as much as a dozen from another hen. Therefore, the only fair way to market eggs is by weight, or by the dozen of a specified weight. Eggs are weighed individually when being graded. For example, each *Grade A Large* egg must weigh at least two ounces. This means that a dozen must weigh 24 ounces or more.

The accompanying table gives a summary of the specifications for grading eggs for sale in Canada.

Canadian Egg Grades

Grades	Size, or Weight per Dozen	Characteristics of Quality
Grade A1 Extra Large	27 or more oz.	Air cell less than $\frac{1}{8}$ " in depth; other characteristics as for Grade A eggs
Grade A1 Large	24 to 27 oz.	
Grade A Large	24 or more oz.	Air cell not more than $\frac{3}{16}$ " deep; yolk outline indistinct; yolk round and well centred; germ spot invisible; no blood spot or meat spot; shell clean, sound, and uniform
Grade A Medium	21 to 24 oz.	
Grade B	21 or more oz.	Air cell not more than $\frac{3}{8}$ " deep; yolk outline visible; no blood spot or meat spot; shell unbroken and reasonably clean
Grade C	Any weight	Yolk not adhering to shell membrane

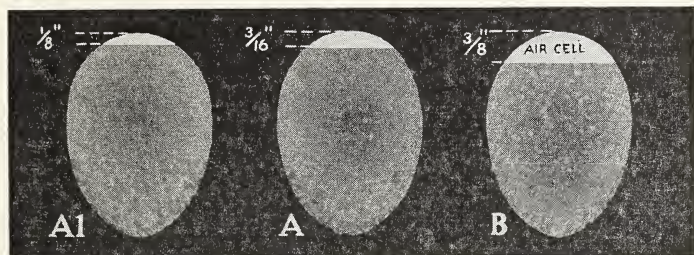


FIG. 24-8. THREE GRADES OF EGGS.

The size of the air cell is an important factor in deciding whether an egg should be graded A₁, A, or B.

Things To Do

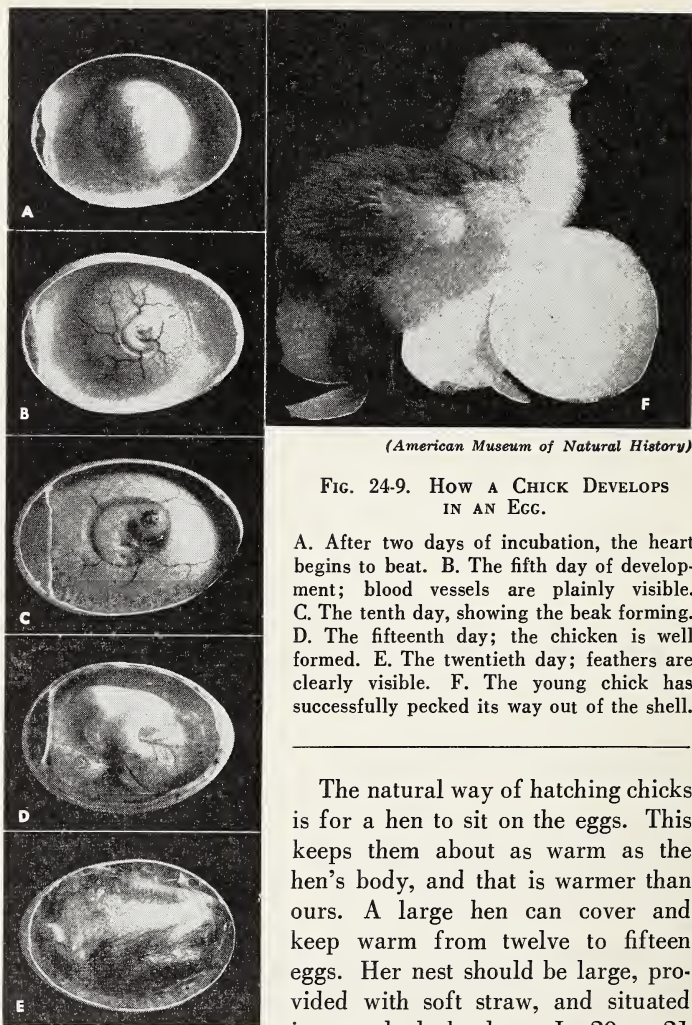
1. Write to the Poultry Products Inspection and Grading Service, Department of Agriculture, Ottawa, for regulations and charts describing the grading of poultry and eggs. Study the literature obtained.
2. Make a candling box. Candle some eggs that are freshly laid and some that are three or four weeks old.
3. Find out whether fresh and stale eggs float equally well. How does the enlargement of the air cell as the egg becomes older help to explain your observations?

Eggs for Chicks

Good Hatching Eggs. If an egg is to hatch, it must be fertile. A male bird must have been kept with the flock of laying hens from which the egg was obtained. Unfortunately, fertile eggs cannot be distinguished from infertile ones until they have been incubated for a few days. Then the fertile egg will show the dark shadow of the developing chicken when candled.

The eggs of excellent layers must be chosen for hatching if the chicks are to become good laying hens. These eggs should be fresh, clean, moderately large, well shaped, and of firm shell.

Incubation of Eggs. The germ spot on the yolk of a fertile egg shows the first stage of development of a living chick. If this germ spot is to develop, it must be provided with warmth, food, and air. Food is provided by the white of the egg; air is present in the air cell; and warmth is provided by the mother hen sitting on the egg, or by an incubator.



(American Museum of Natural History)

**FIG. 24-9. HOW A CHICK DEVELOPS
IN AN EGG.**

A. After two days of incubation, the heart begins to beat. B. The fifth day of development; blood vessels are plainly visible. C. The tenth day, showing the beak forming. D. The fifteenth day; the chicken is well formed. E. The twentieth day; feathers are clearly visible. F. The young chick has successfully pecked its way out of the shell.

The natural way of hatching chicks is for a hen to sit on the eggs. This keeps them about as warm as the hen's body, and that is warmer than ours. A large hen can cover and keep warm from twelve to fifteen eggs. Her nest should be large, provided with soft straw, and situated in a cool, dark place. In 20 or 21

days the chicks in the eggs are fully developed and ready to peck their way out of the shell.

PUPIL INVESTIGATIONS. *How does a chick develop in an egg?*

Study fig. 24-9 and compare what you see in the photographs with what is stated in the description.

Most chicks today are produced by artificial incubation, which means that the eggs are kept warm in an incubator. The temperature in it is regulated to remain between 100°F. and 103°F. Ventilating holes let fresh air in and foul air out. A moist cloth, or some other source of moisture, keeps the air damp enough to prevent the developing chicks from sticking to the insides of the shells.

The eggs in an incubator should be turned twice a day so that the yolks do not stick to one side. Candling the eggs from time to time allows the poultryman to follow the development of the individual chicks (fig. 24-9). If chicks do not start to develop, or if they should die soon after incubation begins, the eggs are taken out and destroyed.

After an egg has been incubated for 20 days, the chick gradually pecks its way out of the shell, then becomes quite active as soon as its feathers are dry.

Care of Baby Chicks

When a chick is hatched, its body contains the yolk of the egg as a store of fat. Therefore, young chicks do not need feeding for two days or so. They should be kept in a thoroughly disinfected brooder or poultry house and at a temperature of 100°F. at first. The temperature should be lowered gradually throughout the following weeks. Chicks need fine straw for scratching and fresh water for drinking. Their feed must supply all materials necessary for the building of flesh, bones, and feathers. "Starting mash", sold by feed stores, are prepared to meet all the needs of growing chicks. Later they are fed "growing mash". Fine grit should always be available to them. Green feeds provide most vitamins, but cod-liver oil or sunlight is necessary to give the vitamin D necessary for proper growth.

Things To Do

1. Visit a commercial chick hatchery. Ask the manager to explain the operation of his incubators and how he feeds and cares for baby chicks.
2. Find out: which neighbouring farmers hatch chicks by setting hens; which have incubators; which buy their chicks. Ask poultrymen the advantages of each method of obtaining chicks.
3. Operate an incubator at school. Take turns at tending it.

Test Questions

1. List four characteristics of a healthful poultry house.
2. State three purposes which must be served by the feed we give hens.
3. Why should hens be fed (1) grit, (2) shell or limestone materials?
4. Make a drawing of an egg broken in a saucer. Label the parts shown.
5. List four facts concerned with the care of eggs that will help a poultry farmer to have high-grade eggs for sale.
6. Why are eggs candled when being graded?
7. State the grade to which each of these eggs would likely belong:
(a) weight $2\frac{1}{4}$ oz.; yolk indistinct; air cell slightly less than $\frac{3}{16}$ " deep;
(b) weight 2 oz.; yolk outline visible; air cell $\frac{3}{8}$ " deep.

Your Word List

Poultry, dual-purpose, membrane, germ spot, yolk, porous, digestive, maturity, incubation, artificial.

16 mm. Sound Films

Ontario Visual Education Branch
Poultry Raising (VG-29)

National Film Board of Canada
Embryonic Development—the Chick (colour)

INDEX AND GLOSSARY

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